This paper represents work done by a UNC-Chapel Hill undergraduate student team. It is not a formal report of the Institute for the Environment, nor is the work of UNC-Chapel Hill faculty.
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In Fall 2013, the Green Labs Committee commissioned our environmental capstone group with the creation of a Green Labs Best Practices Guide. Upon the completion of that guide, our team conducted a more fundamental investigation into other initiatives and programs the Green Labs Committee may be interested in championing. The document attached is a vision memo prepared for the Green Labs Committee that proposes three activities that will allow the Committee to meet its stated goals of reducing the environmental impact and life cycle cost of the labs at UNC Chapel Hill. This vision memo is intended to help the Green Labs Committee set priorities for its resources and imagine how its role may evolve in the coming years.

In Part 1, we propose the launch of a Green Lab Games program that will steer the Committee’s lab outreach efforts. A Green Lab Games program would host a series of interdepartmental contests that encourage labs to make specific equipment-centered changes to green their labs. The committee is uniquely suited for this challenge given its previous experience with the Shut the Sash Campaign in 2010. The Green Labs Committee could serve as program coordinator by managing a team of Eco-Champions in the individual labs. At the end of the section, we outline the design of a Freezer Challenge program that the Committee could launch as early as August 2014.

In Part 2, we propose the development of a Green Chemistry Educational Program for graduate and undergraduate students as well as the general public. A green chemistry experimental design course would teach students how to conduct lab work while using more benign chemicals and reducing the amount of waste in experiments and research projects. These courses will be designed to allow students from multiple disciplines the opportunity to give their perspectives on green chemistry and can only be facilitated through the interaction of faculty from many disciplines. Additionally, a workshop for the general public will be offered to teach basic science literacy and green chemistry. This workshop will be intended to make consumers aware of the health effects of chemicals in their product purchases and how they can live a healthier, safer life.

Finally, in Part 3, we propose that the Green Labs Committee create a written statement of its long-term goals. We recommend that the committee’s long-term plan contains at least two main focuses: investments in energy-efficient lab equipment such as freezers, and energy-efficient lab building design, construction and renovation. We recommend that the Green Labs Committee cooperate more closely with the Energy Management Office in the future to accomplish these goals, since the committee and OEM have common goals and complementary resources. Our team strongly believes that formulating a written long-term plan will benefit the movement for lab sustainability here at UNC. Ultimately, we believe that equipment investments and building design, construction and renovation are areas where large long-term impacts can be made with a moderate amount of resources and institutional cooperation.

Following these three sections, we provide a roadmap which highlights milestones and dates that we recommend the committee meet in order to fulfill its mission of improving the environmental performance of Carolina’s labs. In addition to the roadmap, we provide a table of contacts and a list of references to aid the committee in following up with our work.

Though our capstone has come to an end, our team is very enthusiastic about the opportunity in front of the Green Labs Committee to bring UNC’s labs forward into the environmentally-conscious culture shift that has spread throughout campus. It is our sincerest hope that the research and suggestions present in this memo aid the Committee in reaching that end.
The Green Labs Committee (the Committee) was started in 2008 with two goals: (1) reduce the environmental impact of labs at UNC and (2) reduce the life cycle cost of operating labs at UNC. The Committee brings together students, staff, and faculty from across the University who share in these goals. The committee has had several past successes, including a lab plastics recycling campaign, a Shut the Sash campaign, and vacuum pumps conversion. In order to magnify the Committee’s impact, the Green Labs Capstone has conducted a vision process to help generate specific recommendations for how the Committee can leverage its core competencies to maximize the fulfillment of its stated goals.

We divide our recommendations into three sections. In Part 1, we suggest that the Committee introduce a Green Lab Games program as its central vehicle for outreach and training to the laboratories on campus. We outline the structure of the program, discuss design and administration, and outline a Freezer Challenge that can serve as the first contest. In Part 2, we outline a Green Chemistry education program that will teach students the fundamentals of environmentally safe chemical use during experimental design. We offer suggestions about the content of a workshop that would serve undergraduates and graduates at the University. In Part 3, we propose that the Committee publish a long-term strategy for how the University can address the significant environmental footprint of the labs on campus. We offer suggestions about specific programs other universities have created and describe how other university stakeholders can be involved in greening labs in the long-term.

**Part 1: Green Lab Games**

The Green Labs Committee has stated objectives in its bylaws that it seeks to solicit input and feedback from lab personnel in a variety of lab settings and that it aims to develop a Green Labs outreach and training program. Though several campaigns have been run in the past, a formal, structured campus-wide outreach program still eludes the committee.

We propose that the Green Labs Committee launch the Green Lab Games program in August 2014. The launch of this program will allow the Green Labs Committee to accomplish both cost and environmental impact reduction goals. Green Lab Games is a platform for hosting equipment-centered conservation challenges to champions within the research labs at UNC Chapel Hill. Moreover, a Green Lab Games program folds nicely into two of the objectives already listed in the Green Labs Committee’s initiative letter to solicit the input of lab personnel and to develop a Green Labs outreach program. Best of all, the committee is uniquely prepared to launch this program because of its prior experience with the Shut the Sash Campaign created in partnership with RESPC. The roadmap and program design presented in this document will allow the Green Labs Committee to summon real environmental benefits at the laboratory level.

The UNC Green Lab Games (GLG) program aims to build a culture and a community around sustainable lab practices among the lab researchers on UNC’s campus. The program will catalyze the Green Lab Committee’s effort to serve as the liaison between the lab researchers on campus, the UNC Office of
Sustainability, the Environmental Health and Safety Department, the Office of Waste Reduction and Recycling, and general campus. While these and organizations have sprouted up to engage in conservation advocacy for the residential and office spaces on campus, the research labs remain underserved partly because there is no single institution that recruits, educates, and coordinates conservation activities among potential champions within each lab.

The success of any sustainability program depends on the engagement of the participants. While behavior-based conservation measures only constitute a fraction of the total available conservation opportunities, a competition program is a powerful tool for creating grassroots enthusiasm for broader investment-driven efforts. A GLG program is also an essential tool for building awareness of the environmental problems that labs create for campus.

Other lab conservation programs around the country have been successful by identifying and engaging champions within each lab. The University of Colorado at Boulder Green Lab Games Program administers a program that focuses on engaging scientists with conservation opportunities in their labs and acting as a liaison and facilitate discussion among labs, the Office of Sustainability, Department of Environment, Health and Safety, and the Environmental Center at UC Boulder. The program has been funded partly by the Environmental Center and partly by grants. Of the 400 labs on campus, more than 130 have volunteered an Eco-Leader who acts as the ambassador for conservation efforts in their lab. Recently, the center conducted a lab audit pilot program that performance tested freezer conservation efforts at four labs and produced electricity savings of 120 kWh/day, or six houses worth of electricity (Ramirez-Aguilar 2012).

UC Santa Barbara, on the other hand, has the LabRATS program started by Allen Doyle. The program acts as a home for multiple different lab-centered conservation programs, including chemical surplus sharing, lab waste management, and lab assessments. LabRATS has hired a team of undergraduate interns who steer many of these programs through a grant from the Lawson Valentine Foundation. LabRATS has assessed almost 30 labs at UCSB since inception in 2006 and the program has received recognition by the Journal of Chemical Health and Safety, Science, and in the Sustainable Laboratories and R&D Magazine (UC Santa Barbara 2013). Recently, LabRATS has turned their attention to launching campus-wide freezer challenges and incubator challenges.

Research Lab Constraints
Laboratories possess a unique set of characteristics that demand more from a greening program than do other facilities. Research labs contain hazardous agents and equipment, so green labs programs cannot compromise safety. Research experiments demand the utmost quality in order to provide valuable scientific insights and to be published in scholarly journals, so a green labs program cannot compromise research integrity. Moreover, the research lab environment is high stress and researchers often have several time-sensitive projects and priorities to juggle already before adding in new lab greening protocols they have to learn.

Additionally, primary investigators have little financial incentive to encourage conservation in their labs. Like other research institutions, UNC Chapel Hill has a facilities and administration overhead markup of about 52% on all grant contracts a researcher wins to pay for overhead, within which the electricity, water, and waste bills for a lab are included. Not only does the status quo fail to directly reward researchers for conservation, but the standard overhead financing scheme also complicates performance tracking for individual labs.
Choice of Green Lab contests

The three most common types of green labs programs are campus-wide contests, lab assessment programs, and surplus equipment and chemical exchanges. Campus-wide contests encourage specific changes in the settings or use of particular pieces of lab equipment through friendly competition between departments or universities. In the past, UNC launched a Shut the Sash campaign by placing promotional magnets on the fume hoods. The winning building was awarded a banner outside. Lab assessment programs involve an independent party conducting a comprehensive audit of laboratory equipment in each lab in order to quantify resource usage. Then, a meeting between the green lab experts and a member of the lab creates a list of all the different potential conservation measures and determine which actions should be completed in the near-term. The most successful program in the country is UC Santa Barbara’s LARS program, which has assessed 30 labs at UCSB since 2006. Surplus equipment and chemical exchanges set up university-wide swaps where scientists can look for unused assets that other scientists do not need, saving money and reducing waste. UNC’s Asset Management Trading Post sponsored by Procurement Services is a web portal that lists University equipment that is no longer needed for departments to shop through at a reduced price; however the program is currently underutilized.

These different types of green labs programs were evaluated based on the aforementioned constraints in Table 1. Given that the Green Labs Committee is not a formal institution within UNC, the Green Labs Committee faces strict resource constraints. A Green Labs program hosted by the Green Labs Committee should minimize the total number of hours of administration. Additionally, the program must be tailored to the budgeting capabilities of the Committee leaders’ resources, which are better tailored for educational campaigns instead of capital-intensive retrofits and renovations. The ease of program setup refers to how quickly and with how few resources a program can be launched. Administrative ease refers to how simply an intern could manage the day-to-day operations of the program. Incentives refer to the motivations that a graduate student or a lab PI might have for participation. Engagement describes how involved the scientists are in each program, which is a positive attribute given that greater engagement suggests bigger buy-in to the program.

Lab assessment programs receive very low scores for these categories across the board. These certification programs are difficult to set up and administer because they require deciding upon a complicated national standard, buying lab monitoring equipment and hiring lab auditors, and executing extensive multiple-hour audits of each piece of equipment in the labs. Additionally, the impact is small because the administration is so resource-intensive that only a few labs can be assessed at a time.

Campus-wide contests, on the other hand, held the highest score overall. Judging from the programs at CU Boulder and UC Davis, these programs can be set up in a couple of months and do not require extensive hiring. The majority of the administration is marketing and answering questions, which is fairly easy to do. Food incentives can be provided to participants, who can be as involved as they choose. Most importantly, of the three programs, these contests have the most potential for scaling quickly and moving through campus virally. Though CU Boulder’s program started just three years ago, about 60% of the freezers on campus are now at -70°C and the scientists themselves have become the biggest missionaries of the change on campus. We should note that surplus equipment and chemical exchanges performed well in our analysis, and this represents an additional opportunity should extra resources be made available after the launch of the Green Lab Games program.
Table 1: Comparison of Green Lab Program designs across constraints

<table>
<thead>
<tr>
<th>Program design</th>
<th>Ease of program setup</th>
<th>Administrative ease</th>
<th>Incentives for scientist</th>
<th>Engagement of scientists</th>
<th>Minimal impact to research</th>
<th>Scale of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus-wide contests</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Lab assessment programs</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Surplus equipment &amp; chemical exchange</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

+++ = strong performance
0 = weak performance

While all of these programs could be implemented, **campus-wide contests** present the most appealing confluence of ease of program setup and administration, scientist engagement, and impact to research quality. Accordingly, we propose that the Green Lab Committee launch a Green Lab Games program. A GLG Program maximizes conservation impact within the research quality standard and safety constraints. The program also targets the least time-consuming and resource-intensive projects so as to mitigate costs. Although the Green Labs Committee has identified the creation of a Green Labs certification program as an objective, we recommend that the Green Labs Committee accomplish its outreach objectives first through the pursuit of campus-wide contests, which are a better match for the objectives and resources available to the committee.

Green Lab Games program structure and design

The UNC GLG program fosters sustainable lab behaviors in UNC’s research labs by focusing on providing the infrastructure to spread a positive conservation culture. The program will maximize the engagement of champions within each lab so that they may operate as advocates for green labs ideas internally. This approach compensates for the issue that every single lab has different standards, different equipment, and different resources to offer. Allowing lab-based advocates to determine which best practices pertain to their laboratory space provides an opportunity to customize the Green Labs effort to the needs of individual labs.

The UNC GLG Program may spark a conservation culture shift in UNC’s labs by pursuing three activities:

1. Engage the labs with specific, measurable conservation goals in the form of friendly, incentive-based competitions
2. Create a campus network to facilitate the exchange of lab conservation ideas between green labs advocates
3. Support researchers with resources they need to green their own labs

Administration

Figure 1 outlines the list of organizations and leaders that may be involved with managing the program. As the head of the effort, the **Green Labs Committee** will make executive decisions about the contests to be launched and the prizes to be awarded. The Committee will also work diligently to expand the reach of the GLG program to new affiliate labs by recruiting Eco-champions. The Committee will act as
the primary entity responsible for communicating with the affiliate green labs via emails, once-a-semester lunches, and department meetings with the Eco-champions in each lab. The day-to-day administration of the program will be coordinated by a Green Labs Intern who will report to senior staff in the Office of Waste Reduction and Recycling. This intern will reach out to the labs on campus by presenting at department meetings, printing flyers and posters, blasting listservs, and hosting pizza lunch workshops. In addition, the intern will be responsible for enrolling new participants and answering questions about how the program operates to prospective participants.

Eco-champions will be boots on the ground for the laboratory conservation effort. With support from the PI, the Eco-champions will represent affiliate labs in campus-wide contests. An Eco-champion’s responsibilities include the following:

1. Steer affiliate lab’s participation in Green Lab Games
2. Identify opportunities for energy and water efficiency within the lab and implement changes with assistance from the Green Labs Committee
3. Solicit ideas for conservation measures from other laboratory members
4. Discuss laboratory equipment changes with the PI
5. Educate colleagues about green labs best practices and refer to the Green Labs Committee when appropriate
6. Find a new lab member to assume Eco-champion responsibilities before leaving the lab

There will be several incentives for Eco-leaders to represent their affiliate labs in the Green Lab Games effort. To encourage participation, the Committee can provide food during Eco-champions meetings. The Green Labs Games effort will host several prizes, such as $200 gift card raffles to local restaurants. Both the laboratory and the Eco-champion will receive positive public recognition on the GLG’s website, contest posters distributed throughout the University, campus-wide media, and regional publications.

The Renewable Energy Special Projects Committee (RESPC), a partner organization during the 2009-2010 Shut the Sash Campaign, could provide valuable assistance to the Green Labs Committee in the form of student leadership and funding. Similar to its role during the Shut the Sash campaign, RESPC could provide for magnets, banners, and other promotional materials. Additionally, RESPC could allocate funding for resources that will enable Eco-champions to implement conservation measures. A single green labs fund that could provide for subsidies to replace energy inefficient equipment, providing for mobile storage freezers during freezer cleanouts, gift cards, and pizza parties could enable the Green Labs Committee to roll out an effective campus-wide effort.

Finally, a series of applied learning courses could recruit talented, passionate students who can help with the analytical and management work at the program. Environmental studies capstones, work studies, and paid internships with the Office of Waste Reduction and Recycling could build upon the work that the Fall 2013 capstone has completed. Students in an honors thesis could help analyze the total energy and water savings from the Green Lab Games program. Students could also help the Green Labs Committee to organize new contests and to distribute best practices content to the labs. In addition, a course within the Sustainability Minor could house several student interns to coordinate with the Office of Waste Reduction and Recycling on program development.
First Games: Freezer Challenge

Based on discussions with Allen Doyle at UC Davis and Kathy Ramirez-Aguilar from CU Boulder, we conclude that a freezer challenge should be one of the first competitions run out of the Green Lab Games Program. Given that an Ultra-Low Temperature (ULT) freezer after years of service can consume more than 30 kWh per day, these devices can be more energy-intensive than an entire house. Freezer challenges can generate large energy savings from the reduced load on the HVAC system as well, since freezers add heat load to the building. Freezer care also represents a win-win situation for labs by improving the lifetime of the freezer and reducing the risk of a freezer failure that can be catastrophic for labs.

In a freezer challenge, laboratories earn points for responsible freezer management practices. The focus of the freezer challenge program is freezer temperature tuning: most labs will be asked to adjust the temperature of a ULT freezer from -80°C to -70°C. Freezer temperature reducing can reduce the electricity consumption of a freezer by 2 to 4 kWh per day. The stability of most laboratory samples, including viruses, antibodies, antigens, and nucleic acids is just as good at -70°C, and the added benefit of reduced strain on freezer compressors can actually improve research quality.

As support from the labs grows, Green Labs Committee can encourage additional good freezer management practices that can cost next to nothing to implement. Eco-champions can earn their labs and/or departments points by participating in the following actions.

1. **Freezer cleaning and reorganization**: practicing good freezer management by discarding unneeded samples, properly labeling samples, and moving DNA samples to -20°C not only save freezer storage space, but also constitute good research practice. Defrosting and cleaning out
the filters and coils can make a freezer more energy-efficient and increase the lifetime of the compressor.

2. **Freezer upgrades**: replacing an old freezer with an energy-efficient freezer listed by the Labs21 Wiki, Energy Star program, or other manufacturer can earn participants lots of points.

3. **Share a freezer**: collaborating with other labs to combine samples from two half-empty freezers can allow those labs to unplug a freezer from a wall, which is the greatest way to save energy.

A sample scorecard adapted from CU Boulder is provided in the appendix. Participants earn different amounts of points for good freezer conservation activities depending on the environmental impact and the effort required. Defrosting a freezer earns a participant 1 point and increasing a freezer from -80°C to -70°C can earn a lab two points. Retiring a freezer can earn a participant as many as 20 points.

Several materials that explain proper freezer management and care have been made available by the stakeholders at other Universities who champion their own Green Labs initiatives. A ULT freezer maintenance and operations guide is available from the Store Smart campaign at UC Davis.

**National Freezer Challenge**

The National Freezer Challenge is a competition that began in 2011 with the goal of saving energy, retiring as many freezers as possible, and improving sample access and security. From May to June, each University makes a push to collect as many points on an agreed upon scorecard as possible. UNC Chapel Hill can participate in the 2014 Freezer Challenge against CU Boulder, the University of Florida, Harvard, the CDC, and UC Davis. The National Freezer Challenge presents an excellent way for university labs to build camaraderie and shared goals around lab greening practices. Moreover, the competitive spirit could be amplified by launching a head-to-head competition with Duke University’s own Green Labs program.

The National Freezer Challenge also poses an excellent way for the Green Labs Committee to receive national recognition for the lab greening work that it does. In years past, UC Davis received recognition on the nationally known AASHE website for winning the Freezer Challenge; should UNC put forth a strong effort, other media outlets may be interested in featuring the story.

**Prizes and incentives**

In order to track accomplishments and assign awards, Eco-champions will record their actions in the Freezer Challenge survey that records the Lab ID/representative, the old temperature, the new temperature, and the samples in storage. An example survey devised by UC Davis has been included in Appendix 2.

The most tangible benefit to Freezer Challenge participation will be positive public recognition. Contest posters recognizing the lab contestants will be made for each building, and door stickers indicating participation in the freezer challenge will inform neighboring labs about the scientist’s commitment to lab greening. Appendix 3 presents freezer magnets and lab coat patches that may be used as supplementary materials so that labs and Eco-champions can self-identify their affiliation and commitment to Green Lab Games. Additionally, the Green Labs Committee can work to drum up a Daily Tar Heel article that recognizes the most diligent lab PIs, which will help inform the rest of campus about the good work and values carried out in affiliate green labs.
Cash rebates will provide a tangible benefit to lab PIs that will grant them flexibility in providing for their own lab amenities. CU Boulder currently provides up to a $200 rebate for each freezer that is retired when the lab takes a one-year pledge not to replace the old freezer. Scientists that replace a ULT freezer with an energy efficient one from Labs 21 or Energy Star can also earn a $200 efficiency upgrade rebate once the order has been placed. In addition to cash rebates, gift cards to local restaurants can be offered to all labs that make an entry in the Freezer Challenge survey. The University of Colorado at Boulder offers a $200 gift card raffle, which is large enough to allow an Eco-champion to take their whole lab out to eat—and in the process educate them about the benefits of the freezer challenge. The top department may also win a pizza and ice cream party, a Green Labs Games banner, and other incentives.

Finally, the intangible benefits should not be underestimated. The Freezer Challenge will help connect Eco-champions who share a similar culture, values, and experiences. The competitive nature, coupled with Freezer Challenge lunches and other community development activities, could instill a sense of camaraderie among the researchers outside their own lab groups, which is something that many researchers have articulated is a real need among the scientists at UNC.

Part 2: Green Chemistry Educational Programs

Green chemistry reduces pollution at the source by reducing and eliminating the hazards of using certain chemical reagents, solvents, and feedstocks. The goal is to minimize the use of hazardous materials as well as to develop chemicals that will break down rather than persist within the environment. There are many universities across the nation that have prioritized teaching green chemistry within their curriculum. In order for UNC to remain relevant, there needs to be greater course offerings related to green chemistry and the use of benign chemicals. By taking into account the work of other peer universities as well as the passion of professors within the UNC system, there are several steps that our university could take to increase green chemistry initiatives on campus.

The EPA indicates that green chemistry has 12 fundamental principles, which are noted here:

1. **Prevent waste**: Design chemical syntheses to prevent waste. Leave no waste to treat or clean up.
2. **Maximize atom economy**: Design syntheses so that the final product contains the maximum proportion of the starting materials. Waste few or no atoms.
3. **Design less hazardous chemical syntheses**: Design syntheses to use and generate substances with little or no toxicity to either humans or the environment.
4. **Design safer chemicals and products**: Design chemical products that are fully effective yet have little or no toxicity.
5. **Use safer solvents and reaction conditions**: Avoid using solvents, separation agents, or other auxiliary chemicals. If you must use these chemicals, use safer ones.
6. **Increase energy efficiency**: Run chemical reactions at room temperature and pressure whenever possible.
7. **Use renewable feedstocks**: Use starting materials (also known as feedstocks) that are renewable rather than depletable. The source of renewable feedstocks is often agricultural products or the wastes of other processes; the source of depletable feedstocks is often fossil fuels (petroleum, natural gas, or coal) or mining operations.
8. **Avoid chemical derivatives**: Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.
9. **Use catalysts, not stoichiometric reagents**: Minimize waste by using catalytic reactions. Catalysts are effective in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and carry out a reaction only once.

10. **Design chemicals and products to degrade after use**: Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

11. **Analyze in real time to prevent pollution**: Include in-process, real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.

12. **Minimize the potential for accidents**: Design chemicals and their physical forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

### History and Importance of Green Chemistry

Green chemistry is not a new initiative (green chemistry has been a concept since the 1970s), but its appeal has been steadily growing. Chemicals have developed a negative stigma in the last several decades through association with environmental disasters such as the chemical factory gas leak incident in Bhopal, India in 1984. Considered one of the most deadly industrial accidents of our time, the Union Carbide pesticide plant’s leak caused the death of 8,000 people and disease for 8,000 more. Chemicals can be extremely hazardous and should be handled with care; alternately, there is also room for the use of benign chemicals in many cases. There are three facets of green chemistry’s importance and its use in eliminating and reducing risk within society and within our environment.

Green chemistry helps alleviate the negative impacts of industry on human health and the environment, as well as on the economy and business. Human health is improved when fewer dangerous chemicals are in the air, water, food, and products that we are consuming every day. The environment and our ecosystems are fragile, and by using both fewer chemicals and degradable and more benign chemicals, we lessen the impact society has on the environment. Several progressive businesses are now looking for ways to be environmental stewards in their product development efforts: by incorporating green chemistry, new products are not only less hazardous, but they also change the culture of product design and help hold other companies accountable for reducing the hazards that could be caused by using their products. Green chemistry also saves energy, reduces waste, and makes companies consider how to improve the integrity of their product.

### Interdisciplinary green chemistry course offerings

We recommend that UNC develop interdisciplinary green chemistry courses at both the graduate and undergraduate level emphasizing the importance of understanding our choices in chemical development, and how these choices impact society and the environment. There are several peer universities that have instituted comprehensive Green Chemistry programs. UC-Berkeley created the Berkeley Center for Green Chemistry. As part of their program, they have developed interdisciplinary collaborations between many of their graduate schools, in order to create a comprehensive system that works to create novel processes for developing/using benign chemicals. By integrating this understanding of benign chemicals with public health initiatives to increase awareness of the negative health impacts of more toxic chemicals while also working with the school of engineering and other entities, UC-Berkeley has developed a full cycle of (benign) chemical development, manufacture, use, and disposal. The info-graphic of these collaborations can be reviewed in Appendix 4.
We recommend that UNC launch a trial course at the graduate level beginning in Spring 2015. The course could be modeled after Berkeley’s trial course in Spring of 2011 at UC-Berkeley called “Green Chemistry: An Interdisciplinary Approach to Sustainability.” This course would be taught at the graduate level by eight professors from multiple disciplines including environmental health science, public health, and business and the course would be made available to graduate students from disciplines including chemistry, engineering, business, etc. The course at Berkeley received an overwhelmingly positive response from the enrolled students. Interdisciplinary course work benefited these students, as they were able to gain perspectives from multiple fields through class project collaboration, small group discussions, and learning from other’s passions. By offering a course of this nature, UNC would be able to develop industry leaders for multiple fields with perspectives of environmental stewardship, chemical use, and development. These future leaders would understand how their decisions to use certain chemicals can have health effects, both in the long and short term.

The Green Labs Committee can address the primary barrier to launching an interdisciplinary green chemistry course by assuming responsibility for organizing the green chemistry interdisciplinary collaborative efforts. Several champions from multiple departments will need to work together in order to develop a course offering of this nature. There are certain courses within the School of Public Health that relate to the environmental health impacts of chemicals. However, in order to make the course relevant to students from multiple fields, there must be additional content developed. Dr. Ball of the Environmental Sciences and Engineering Department at the Gillings School of Public Health believes that the creation of these collaborations will be a challenge, as many departments do not have significant interactions that would lead to the development of these types of courses.

**Experimental design course offerings**

We recommend the Green Labs Committee add to the experimental design course offerings and launch a course focused exclusively on green chemistry. According to two of our interviewees, there have been several instances where university professors have taken it upon themselves to develop lab experiments and make time within their course schedules to place green chemistry into the curriculum, in order to make it part of what these students are learning. Speaking with Dr. Eskew, Director of the Undergraduate Labs and professor of Organic Chemistry, revealed some examples of previous accomplishments at the undergraduate level, which are listed below:

1. Chemistry 241 Lab (Analytical Chemistry) – A few years ago, Dr. Tiani (the director of the analytical labs) eliminated an extraction experiment that used dichloromethane—a halogenated chemical substance that often persists in the environment and is a possible carcinogen. It has to be incinerated at higher temperatures than non-halogenated chemicals.

2. Chemistry 262 Lab (Organic Chemistry II) – There was an oxidation reaction experiment (converting an alcohol to a ketone) that usually calls for chromic acid, a harmful chemical substance that has now been substituted with bleach. During the experiment, students also learn that bleach is much easier to dispose of and break down than chromic acid. Dr. Krumper was in charge of these experiments and implemented this change some time prior to 2012.
3. Chemistry 262 Lab (Organic Chemistry II) – There was an experiment for this lab that called for dichloromethane; the directors have now eliminated the use of dichloromethane from this experiment.

4. Chemistry 262 Lab (Organic Chemistry II) – The directors completely eliminated an experiment that used para-Cresol (p-Cresol.) Although this particular substance is not particularly toxic, it has to be extracted from coal tar by a two-step industrial process, which is a large energy consumer. The department eliminated this experiment and expanded one of the other experiments over a two-week span; they currently are planning to replace the experiment with a lab that is based on green chemistry concepts.

5. Chemistry 550 Lab (Undergraduate Chemistry Majors Capstone Lab) – They have implemented the use of formaldehyde rather than some of the more toxic and hazardous substances they had been using. They plan on doing more green chemistry initiatives within this lab; however, they have started by taking out the most hazardous materials through the formaldehyde substitution. (This change with the experiment was on a trial run this semester and there may be a green chemistry explanation component within the lab manual if this change is a solidified lab curriculum change.)

The launch of a green chemistry experimental design course fills a crucial niche on campus. While some of these initiatives at the undergraduate level have been brought into the lecture material as well, the professor must set aside time to teach this additional material; often the professor is already highly constrained by the core course material. A course of experimental design, for both the graduate and undergraduate level, would benefit students by allowing them to think through the complexities of the chemicals they are using with some set goal in mind. By looking at certain synthesis labs and understanding how changes can be made to the syntheses by using more benign solvents or reducing the amount of waste, students would have an industry edge in working within the chemical industry and would be better able to think on their feet with certain skills. A similar program at UC Berkeley called Engineering and Health Impact Methods of Green Design has been wildly successful. This course offers assessment tools, with alternatives for sustainable design. By offering a course of this nature, UNC would be able to develop chemistry student’s levels of understanding related to design and also gaining further perspective on the engineering that their findings would require.

Green chemistry workshops for students and the general public
A monthly green chemistry workshop should be offered to the general student body, staff, and the general public. A faculty speaker will bring in his or her perspectives on green chemistry and how it impacts their specialty and some of their research. This will provide students and the public multiple perspectives about how green chemistry is important to many aspects of our lives. The Green Labs Committee can borrow ideas from Carnegie Mellon University, which has engaged the general public through its Institute for Green Sciences. Carnegie Mellon has even created a free, online beta course focusing on green chemistry that addresses how our products and consumables affect the environment and society.

This public workshop will build upon a growing public interest in safe, sustainable chemistry. Dr. Eskew noted that chemical use and development is now being brought to the forefront of people’s minds by
advocacy groups hoping to teach a basic level of science literacy in order to encourage informed purchasing decisions. With the support of university professors and faculty, green chemistry could become a relevant topic on our campus and could lead to more formal courses for non-science students who are interested in the impacts of chemical use and want to understand sustainable development and design.

Part 3: Long-term strategy recommendations
The Green Labs capstone proposes that the UNC Green Labs Committee formulate and publish a written long-term strategy that will contextualize and clarify short-term projects, while keeping long-term efforts in the committee’s discourse. Much of the focus of this Fall 2013 capstone course has been on short-term efforts to improve lab behaviors. However, this section of the recommendations report will outline two main areas where the committee could start its long-term strategy: lab building renovation/construction and equipment investments.

Background
At the beginning of our capstone project, our team was trying to determine which aspects of lab greening we should dedicate our efforts to in order to have the maximum impact. Allen Doyle, an expert in lab greening at the University of California-Davis, stated that although water conservation, waste reduction and other efforts are important, lab energy use constitutes the greatest environmental footprint. On average, labs consume 4-5 times more energy per square foot than other building uses, such as offices. Therefore, the recommendations in this section of the report will focus on strategies for conserving energy in UNC’s lab space. UNC has stated several goals pertaining to efficient energy use, one of which is that by 2015, energy consumption per square foot will be 30% lower than 2003 levels. Also, the university has committed to achieving “climate neutrality” by 2050. This report will describe several ways that the Green Labs Committee can take steps towards meeting these and other long-term goals.

A previous section of this report has already outlined the constraints that the Green Labs Committee faces. Since the Committee is not a formal institution within the university, it has limited financial means. However, the Committee has had success in the past when working in cooperation with better-financed groups. For example the Shut the Sash campaign was run in coordination with RESPC, which benefits from a $4 per student semester fee. This section of the report will encourage the Green Labs Committee to accomplish its long-term goals by leveraging the expertise of its members and partnering with campus stakeholders that hold important resources. Certainly, the costs of renovating a lab building or investing in new freezers are high, but the Green Labs Committee can make meaningful contributions to these processes while relying on other entities, such as the Office of Energy Management, to fund these efforts.

Equipment Investments
In the long term, the Green Labs Committee should consider partnering with the Office of Energy Management to launch a rebate program to incentivize the purchase of energy efficient lab equipment. In September of 2013, we interviewed Randy Smith, who is leading efforts to promote lab greening at Duke, particularly in their Biology department. One medium-sized investment that Smith said was very
successful so far was energy-efficient freezers. Specifically, Duke had invested in several ultra-low temperature (ULT) freezers that used new technology, did not require compressors, and used about half the energy of other ULT freezers. In order to accommodate the higher upfront cost of buying a $14,000 energy-efficient freezer versus an $8,000 conventional ULT freezer, Smith convinced the College of Arts & Sciences to put forward the $6,000 initial investment in exchange for receiving the energy savings over the lifetime of the freezer. Since the energy efficient ULT freezer consumed about 50% less energy than older, conventional ones, this resulted in annual energy savings of between $1,000 and $1,500 per freezer per year, meaning the payoff time was 4-6 years. Duke experienced additional savings due to decreased maintenance costs (no compressor repairs) and decreased heat load.

UNC’s program must be modified to accommodate the fact that funding works differently at UNC than at Duke because UNC is a publicly funded university. UNC can learn from the sustainability program of neighboring NC State. In 2011-12, NCSU’s Energy Management Office, managed by Paul McConocha, tried a freezer rebate program. NCSU’s Energy Management Office paid 50% of the cost for six new freezers that used half the energy (~15 kWh per days vs. ~30 kWh per day). In less than a full fiscal year, they realized 32,850 kWh in energy savings (approximately $2,500). McConocha says that his office learned several lessons from this rebate program, which they hope to repeat in the near future. He recommended reaching out directly to PIs and departments to ensure a sizable level of participation. He also recommended starting an initiative like a freezer rebate program at the beginning of the fiscal year, when researches have more money to invest in upgrading their equipment. And while it might not be possible or practical to get UNC’s College of Arts & Sciences to invest in energy conserving ULT freezers, there are sources of funding that exist to encourage energy conservation at UNC.

Recent legislative developments also provide insight into how strategic equipment and building renovation investments can be financed. Currently, the North Carolina legislature appropriates state money to pay the energy bills for about 70% of UNC’s buildings, including all laboratory buildings. There is a disconnect between the legislators who appropriate money for UNC’s energy bills and the people at the university level who make decisions about energy use. Fortunately, in 2009 the legislature passed HB 1292, which states that public universities can retain any energy savings into the next fiscal year, provided that 60% of that money is spent on additional energy conservation measures. In 2013, UNC was able to keep about $1.6 million thanks to HB 1292, and they sent that money to the Office of Energy Management (OEM). According to OEM director Chris Martin, OEM would love to invest that money in laboratory buildings, which provide some of the highest return on investment of all campus conservation projects. Chris mentioned that freezers were a great example of a medium-sized investment that the university can make using funds from HB 1292. The Green Labs Committee should make an effort to familiarize itself with this and other energy-saving equipment in order to work with OEM and influence how that money is spent. Links to information about the freezers are provided in the References section below.

Lab Building Construction & Renovation

To avoid infrastructure lock-in and the unnecessary energy consumption and costs that can result from it, the Green Labs Committee should plan to increase its participation in lab building construction and
renovation in the future. Lab buildings last a long time, often several decades, and their designs can have a huge impact on the amount of energy they consume over their long lifetimes. The process for building construction and renovation is complex, and involves a lot of institutions within the university. The biggest player is the Capital Projects division of the Facilities office, which has a schedule of new building construction. However, OEM provides advice on how to make building design more energy efficient; Environment, Health and Safety (EHS) focuses on building safety, and many other entities have input in the process. The Green Labs Committee, in cooperation with OEM, could have a significant impact on lab building design if it chooses to get involved in this process.

According to OEM director Chris Martin, perhaps the most important decision in designing a green lab building is the HVAC system. Lab space has unique specifications for flushing air into and out of certain areas that exceed normal requirements for other types of space. This capstone team does not claim to have expert knowledge about exact specifications, but the Green Labs Committee certainly might. For example, if significant energy savings can be produced without influencing research quality at a lower rate of air flow, perhaps eight air changes per hour, and current building standards are set to 16 changes per hour, the committee could provide its expertise in the design process to reach a number that is safe but also conserves as much energy as possible. The committee should also give input into other aspects of building design. Currently, the group of new building decision-makers, including OEM, has a stated goal of achieving LEED Silver certification for newly constructed campus buildings. Green Lab Committee members should engage with decision-makers and see if lab buildings can reach a higher certification level, such as Gold or Platinum, than other building types.

The Green Labs Committee, which includes lab workers who know lab conditions very well, could help generate leads for large equipment investments to send to the Office of Energy Management. Certain large equipment investments, like more efficient autoclaves and fume hoods, are large enough to require the renovation of entire buildings, floors or sections. OEM has replaced some older, less efficient fume hoods in UNC labs with newer, more energy-efficient models. However, OEM’s Chris Martin says that his office is too stretched to define projects to put their HB 1292 money towards. For example, a committee member may know that their building contains older fume hoods that would be perfect for replacement with funding from OEM. By communicating this need for fume hood replacement with OEM, the committee can help to make these green investments happen.

If the committee plans to act on this report’s recommendations, namely to focus on building construction/renovation and equipment investments, cooperating with other institutions will be very important. In particular, UNC Office of Energy Management can be a huge resource for the committee to use. OEM has expertise about energy conservation practices, and they are always looking to be presented with new ideas about where to focus their resources. Crucially, they have funding to devote to energy-saving projects in labs and elsewhere, which perfectly matches the committee’s ability to develop project ideas but lack of finances. Getting involved with OEM and the other players in building and renovation decisions here at UNC is an important step. Finally, it is important to stress that great ideas about green labs are being discovered and implemented all the time across the country and right here in the Triangle. This report drew upon the lessons learned at NC State and Duke, and we suggest
that the Green Labs Committee try to open dialogues with resourceful green labs people, both locally and nationally, whenever possible.

Conclusion
The Green Labs Committee serves a very important purpose here at UNC, and has produced tangible results in the areas of lab recycling, water aspirators, and the Shut the Sash campaign. We believe that the Committee can amplify its efforts by focusing its resources on three program areas: a Green Lab Games program, a green chemistry education program, and a long-term strategy report. A Green Lab Games program will consolidate all of the outreach efforts into specific, measurable, realistic expectations of the labs and establish a direct communication channel with intra-lab advocates. The green chemistry program will educate future scientists in green experimental design through leveraging UNC’s established education channels. The creation of the program will require the engagement of champions across the academic disciplines of the university. Finally, the production of a written statement of UNC’s 2050 lab greening goals will serve as a road map for future lab greening efforts, whether they are behavioral or infrastructural. This long-term vision will equip the Committee with the focus necessary to influence future investments with lab greening priorities.
### Suggested roadmap

<table>
<thead>
<tr>
<th>Action Items</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring</td>
<td>Fall</td>
<td>Spring</td>
<td>Fall</td>
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<tr>
<td>Set goal and vision for Green Lab Games</td>
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<tr>
<td>Freezer Challenge internship</td>
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<tr>
<td>Prepare Freezer Challenge webpage</td>
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<tr>
<td>Press release announcing program launch</td>
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<tr>
<td>20 Labs participating in Freezer Challenge</td>
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<tr>
<td>50 Labs participating in Freezer Challenge</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>100 Labs participating in Freezer Challenge</td>
<td></td>
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<tr>
<td>Arrange Green Chemistry Educational program</td>
<td></td>
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<tr>
<td>Graduate trial course launched</td>
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<tr>
<td>4 grad classes incorporate green chemistry</td>
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<tr>
<td>Launch of monthly public workshops</td>
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<tr>
<td>4 undergrad classes incorporate green chemistry</td>
<td></td>
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<tr>
<td>Prepare Long-Term Strategy Goals and Vision</td>
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<tr>
<td>Publish Green Labs Long-Term Vision report</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Launch of Freezer Rebate program</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HB 1292 Green Labs Project Generation input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Useful Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen Doyle</td>
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<td><a href="mailto:rrsmith@duke.edu">rrsmith@duke.edu</a></td>
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<tr>
<td>Paul McConocha</td>
<td>NC State Energy Program Manager</td>
<td><a href="mailto:prmcconoa@ncsu.edu">prmcconoa@ncsu.edu</a></td>
</tr>
</tbody>
</table>
References


Appendix 1: Freezer Challenge Scorecard (adapted from CU Boulder)

### Scoring For Freezer Challenge 2013
**Higher Education and Federal Research Laboratories**

- Points are awarded per freezer or refrigerator.
- To clean out shelf space, samples may be processed by alternative storage methods such as freeze-drying, which may be done throughout the Freezer Challenge. If you have already cleaned out your freezer, please make your best estimate of the amount of discarded frozen inventory.
- Campus incentives and rebates are provided to promote lab involvement.

### Points 2013 Description

<table>
<thead>
<tr>
<th>Points 2013</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus Participation Points</td>
<td>20 Points per campus just for joining and submitting data</td>
</tr>
<tr>
<td>Individual Participation Points</td>
<td>1 Point per PI whose group accumulates any other points</td>
</tr>
<tr>
<td><strong>BASIC POINTS</strong></td>
<td>ULT Freezer: -30°C or -40°C; Refrigerator: -20 °C or below</td>
</tr>
<tr>
<td></td>
<td>Points correlate to approximately the equivalent of one point per kWh/day savings.</td>
</tr>
</tbody>
</table>

### Good Management Practices

Completing multiple steps accumulates points:

- **Step 1:** Defrost and remove dust from intake or coils
  - 1 point per ULT freezer
  - 0.5 point per Refrigerator

- **Step 2:** Clean out (per ft³)
  - 1 point per ULT freezer
  - 0.5 point per Refrigerator

- **Step 3:** Sample Inventory
  - 2 points per ULT freezer
  - 1 point per Refrigerator

- **Step 4:** Inventory on file
  - 2 points per ULT freezer
  - 1 point per Refrigerator

### Temperature Tuning

- Database or spreadsheet with 95% complete inventory.

[https://sites.google.com/site/labfreezercompetitioncuboulder/](https://sites.google.com/site/labfreezercompetitioncuboulder/)
<table>
<thead>
<tr>
<th>Campus Participation Points</th>
<th>20</th>
<th>Points per campus just for joining and submitting data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chill Up! (points per 10°C)</td>
<td>1</td>
<td>Labs that already have their freezers at -70°C also receive points. Data will be compiled. A campus award given for greatest portion of ULT's warmer than -80.</td>
</tr>
<tr>
<td>Samples moved to -20 °C or RTSS</td>
<td>1</td>
<td>One point per cubic foot of samples moved. DNA extracts at -20°C is standard practice. Many samples are stable at -20 for intervals up to a few years.</td>
</tr>
<tr>
<td>Storage Temperature Citations</td>
<td>2</td>
<td>2 points for example of storage temperature test and results; 5 points for literature citation on storage temperature tests and results. Room temperature to freezer temperatures to liquid nitrogen.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retirements and Upgrades</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Retirement</td>
<td>20</td>
</tr>
<tr>
<td>Appliance upgrade (per kWh/d)</td>
<td>1</td>
</tr>
</tbody>
</table>

Retirement includes a 1-year pledge to not replace. Multiple points per door for glass door refrigerators. This meets the ultimate challenge! May be eligible for additional subsidies.

Appliance upgrade (per kWh/d) must be validated with kW or Amp measurements or data from Labs21 Wiki, Energy Star, or Manufacturer.

<table>
<thead>
<tr>
<th>Cutting Edge Practices</th>
<th>Points are not necessarily representative of kWh/day savings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharing (per additional PI)</td>
<td>4</td>
</tr>
<tr>
<td>Inventory Barcoded</td>
<td>2</td>
</tr>
<tr>
<td>Trying RTSS</td>
<td>5</td>
</tr>
<tr>
<td>Adopting RTSS</td>
<td>2</td>
</tr>
<tr>
<td>Reduced cooling load in building (per kWh/d)</td>
<td>1</td>
</tr>
</tbody>
</table>

Points for additional PIs that store samples in this freezer and thus avoid purchasing a freezer or are able to retire one.

Submit photo of barcoded storage containers, or display with a visit.

RTSS must be tried out on at least one well plate of DNA (96 samples) or 25 tubes of RNA. May be eligible for additional subsidies.

Adoption includes at least 2 plates of DNA or 50 tubes of RTSS. Points are awarded per plate of DNA or per 25 tubes of RNA. May be eligible for additional subsidies.

Measured or modeled and documented by energy manager. Alternate calculation: 1 point per 10 CFM air flow reduction. Must be annual net HVAC reduction due to relocation, Chill Up! or retirement.

Fun Campus Awards:
Frostiest Photo—Send your images to apdoyle@ucdavis.edu. RipVan Winkle Award—Oldest sample discarded.
### Appendix 2: UC Davis Temperature Tuning Recording Survey

![UC Davis Logo]

#### 2. Freezer model and serial numbers (or UC Davis inventory number starting with year)

<table>
<thead>
<tr>
<th>Freezer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
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</tbody>
</table>

#### 3. Previous and New Temperature Settings

<table>
<thead>
<tr>
<th>Freezer</th>
<th>Previous Setting</th>
<th>New Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 4. WHAT are you freezing? Kindly indicate the sample types in each freezer that are important to your research.

- DNA
- cDNA
- RNA
- Proteins, incl enzymes
- Lysates
- Physiological fluids
- Competent cells
- Plant tissues
- Animal tissues
- Swabs
- Bacteria
- Yeast/Fungi
- Viruses
- Aqueous/Buffer suspensions
5. **BONUS: HOW LONG do you store samples?** Kindly indicate sample types and storage duration in each freezer. Your answers will help write storage guidelines, AND IT WILL GAIN BONUS POINTS FOR YOUR LAB.

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Freezer 1</th>
<th>Freezer 2</th>
<th>Freezer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CDNA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RNA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Proteins, incl enzymes</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lysates</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Physiological fluids</td>
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<td></td>
<td></td>
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<tr>
<td>Competent cells</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant tissues</td>
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<td></td>
<td></td>
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<tr>
<td>Animal tissues</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Swabs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Yeast/Fungi</td>
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<td></td>
<td></td>
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<tr>
<td>Viruses</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Aqueous/buffer suspensions</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Glycerol suspensions</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dried tissues/extracts</td>
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<td></td>
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<tr>
<td>Reagents &amp; Extraction Kits</td>
<td></td>
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</tbody>
</table>
Appendix 3: Green Lab Games Lab Collateral

_Design for Freezer Challenge Magnets_. These magnets will be handed out to be placed on ULT freezers (also known as -80°C freezers). The magnets are branded with the colors and the seal of the Green Labs Committee. Additionally, the slogan (“-70° is cooler”) embraces the fun and competitive theme of the Green Lab Games program.

_CAROLINA_  
_FREEZER CHALLENGE_  
_-70° is cooler._

_ Lab Coat Patch Designs for Eco-Champions_. Volunteer lab leaders of the Green Lab Games program will be offered a patch with the Green Lab Games seal below. These patches will allow Eco-Champions to demonstrate their commitment to environmental values in the labs and spread awareness of Green Lab Games.
**Green Lab Games Equipment Stickers.** Other equipment-centered challenges will be based on turning off discretionary plug-load equipment such as incubators, autoclaves, and chilled centrifuges. “Turn me off” stickers designed below will be handed out to Eco-Champions to distribute around the labs.
Appendix 4: UC Berkeley Green Chemistry stakeholder collaboration map