ACS Green Student Chapter Activity: Organizing a Field Trip

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Sustainable and green chemistry in simple terms is just a different way of thinking about how chemistry and chemical engineering can be done. Over the years different principles have been proposed that can be used when thinking about the design, development and implementation of chemical products and processes. These principles enable scientists and engineers to protect and benefit the economy, people, and the planet by finding creative and innovative ways to reduce waste, conserve energy, and discover replacements for hazardous substances.

It's important to note that the scope of these green chemistry and engineering principles go beyond concerns over hazards from chemical toxicity and include energy conservation and waste reduction, as well as life cycle considerations such as the use of more sustainable or renewable feedstocks and designing for end of life or the final disposition of the product.

By incorporating sustainable and green chemistry into your student chapter's activities you can:

- Become a spokesperson on your campus for sustainability and the solutions chemistry can bring through green chemistry
- Start a movement of sustainability across your campus and in the community
- Make a difference through chemistry
- Have a positive impact on human health, the environment & the future
- Improve the "image" of chemistry

Chapters who engage in at least three green chemistry outreach and educational activities during the school year are eligible to win a Green Chemistry Student Chapter Award.

Green Chemistry Themes to Consider[1]

It is better to:

Prevent waste than to treat or clean up waste after it is formed
Minimize the amount of materials used in the production of a product
Use and generate substances that are not toxic
Use less energy
Use renewable materials when it makes technical and economic sense
Design materials that degrade to innocuous products at the end of their usable life

[1] Middlecamp, Catherine, ed. *Chemistry in Context: Applying Chemistry to Society*. 8th ed. New York: McGraw Hill, 2014. Print

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Seeing is believing and sometimes just what's needed to show that green chemistry is not only important but also happening all around. Several student chapters have organized field trips to get participants off campus and into research facilities to learn first-hand how green chemistry is already being applied.

Students at the University of Tennessee at Martin and the Pontifical Catholic University of Puerto Rico each took visits to manufacturers of biofuel, receiving tours of the labs, explanations of green chemistry in action and, in Puerto Rico, even a hands-on experience. In Pennsylvania, Alvernia University students went to the Environmental Recovery Corporation to see the company's hazardous-waste recycling and recovery processes.

The possibilities of where to go for a field trip are endless, which can be overwhelming. How do you go about choosing a location, getting in contact with the right people, or finding the funds to make it happen? Use this guide to help organize a green chemistry field trip at your college or university.

Who's going and where to?

Before anything else decide how broad the invitation will be. It can be as closed as only including members of the student chapter or as open as the entire campus. No matter who or how large the target audience is, you'll need to get people to sign up. Create a simple sign-up sheet with name, email address, phone number, and whether or not they've paid (if relevant).

If you're worried about no-shows ask for a cash deposit of $5-$10 that will be returned or, if the trip will cost something, ask participants for the money in advance. **There is always the possibility of adding incentives to attract participants**. For example, try to include a discounted lunch at a restaurant through school or department funding. **Get faculty on board:** will any professors in relevant fields offer extra credit for students who attend? All it takes is a quick email or meet-up to explain the purpose of the trip and how it's relevant to the curriculum. Just as with advertising, be direct, keep it simple, and do some research before asking for support. There's a chance that your college or university will require a faculty member to go along.

These are things that need to be discussed and decided among your student chapter before choosing a location, but **don't actually send emails or make advertisements until the location is confirmed**.

If no one planning the event can think of a business, lab, or factory to visit, it's a good idea to start asking around. Are any of the **chemistry faculty members** involved in green chemistry research? They may be aware of a nearby facility that would be appropriate to visit, past field trips that have been successful, or companies that have employed alumni.

The Green Education Materials for Chemists (GEMs) database has a map with the locations of green chemistry activities all over the world. Check that out here to see if there's anything listed near your school. If you're still drawing a blank, **don't give up!** It's time to search the wide open sea of the internet. Try searching "green chemistry" plus your state. Also look up museums in your area to see if they are planning to run any relevant exhibits.

Remember, **green chemistry is not synonymous with sustainability** (to learn more, see Appendix A). Additionally, larger chemical manufacturing, formulating, or design companies that do not focus solely on green chemistry may have a green research division. It doesn't hurt to ask.

- Once you've selected a potential location (and a couple back-ups), give them a call. Most companies will list a phone number on their website.
- Be patient, and call during normal weekday business hours (9-5).
- They'll likely want an estimate of **group size, date, length of visit and if you're expecting anything** like a tour or hands-on experience. In addition, be sure to explain the purpose of the visit and if you're tying it into a particular aspect of the curriculum.
- Make it clear that it is to teach students about green chemistry and let the phone call be a conversation.
- **Ask what programs they are excited about.**
- To help them tailor the visit to your needs, let them know if the group will be science students or more interdisciplinary.
- Remember, you're asking for a favor so be courteous and **thank them for their time** even if they decline a visit.
- Confirm the date again a day or two before the visit (because everyone forgets things!).

Additional Considerations:

- Schedule a date that will not only be convenient for members of your student chapter to dedicate time but also choose a slow time of the school year. Try to **avoid mid-terms and finals, holidays, and conflicts with major campus events.**
- Make a timeline when organizing a field trip. Some things can be arranged months in advance.
- What's the **cancellation policy**? In the event of bad weather, for example, be sure to let participants and the hosting facility know as soon as possible that the trip is cancelled and if/when it is to be rescheduled.
- **How long will the trip be?** Both the host and the participants will want to know the amount of time they'll be spending. If it's going to be a day trip, is it in the budget to provide lunch? School catering facilities may be able to provide bagged lunches as a part of student meal plans if notified in advance.
- Know how many people are on the trip and don't leave without anyone! It might feel funny to count college students, but **you never know who's still in the bathroom**.

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How to Advertise

Who will attend the field trip if no one knows about it? One of the most important parts of hosting an event is advertising. Here are a few tips for getting better attendance when designing posters or spreading the word online.

- Remember, you will know the details about how great the trip will be better than anyone looking at your flyers or posters. Sometimes it's best to take a step back when you're very familiar what's at hand. Think of how those who have never heard of green chemistry would perceive the ads and tailor your message around the perceptions of the intended audience. Do some research to find out what they are most likely to care about and adjust the program to fit their needs.
- Always approach advertising in a way that is SIMPLE, DIRECT, and RELEVANT. You don't need a sassy/witty marketing push. Stick true to your message and the purpose of the field trip. People can instantly sense authenticity so try and be as clear as possible.
- Make sure you have information access points for your program, such as a Facebook page, Tumblr or WordPress sites, to give more behind-the-scenes look. Also try to get your own URL and make it as short as possible for advertisements.
- If you have an online presence, make sure all the facts are straightforward and easy to find. A simple page with about the main details (time, date, place, description) and contact information should suffice. Find a tech-savvy friend to help you set up a website if you aren't sure how. There are a number of fairly simple drag and drop webpage builders.

Where to Find Funds

Many professors and administrators will recognize that field trips are a valuable part of an education. Still, a field trip organized by your ACS student chapter will have to be presented in a convincing way in order to receive funds. Drawing up a budget ahead of time that details exactly where money will be spent is really important when applying for any kind of grant. Transportation, admission (if it's a museum), and food (if provided) will most likely be the largest expenditures.

Obviously, you can charge students who sign up for the trip to help pay. Just remember, you're inviting fellow college students to spend money, so keep their cost as low as possible.

Existing Funds

University grants and the department budget may have money available for student projects. Ask faculty members and browse your school's website for opportunities to apply. There may be an organization on campus, such as student government, that allocates money for student organized events.

Food

Sometimes the university food facilities will provide catering if notified in advance that will be covered by the student's normal meal plans. Just be sure to ask ahead. If participants should bring their own bagged lunch let them know during sign-ups.

Transportation

The university is probably partnered with a charter bus service for other field trips or sports team events and may be able to offer a reliable service with a discounted rate. Using university transportation is likely the safest and most cost-effective option. Public transportation, if available, is also an option, but students may request reimbursements.

Fundraising

There are about a million different ways to fundraise on campus. A few common ones include a bake or craft sale, raffle, or car wash. You may be required to notify your university or college when, where, and why you plan to hold a fundraiser

Prepare Participants

Make sure those going on the trip know what they're in for. During sign-ups, tell them how long it will be, how far away it is, if there are clothing requirements like closed shoes, and whether or not they will need money for food. Provide a handout with introductory information (like this) for non-chemists to read on the bus or before the trip so they know what they're looking at. This might seem like something you had to do as a third grader - and it probably was - but teachers give handouts on field trips for a reason. They're intended to give background and highlight the purpose while maintaining the focus of the trip. Depending on the target audience for your trip, many participants will never have heard of green chemistry.

Email the trip itinerary/schedule out a couple days ahead of time and go over it again at the beginning of the field trip.

If there are any forms associated with student safety and field trips (such as waivers or emergency contact information) be sure they are filled out and turned in to the appropriate department before the day of the trip. Contact anyone who has not filled theirs out.

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Field Trip Checklist

- [ ] Decide who may attend
- [ ] Select a location
- [ ] Apply for funding
- [ ] Discuss details with the business/facility
- [ ] Make a cancellation/rescheduling plan
- [ ] Organize transportation, food, and incentives
- [ ] Make a schedule
- [ ] Advertise, advertise, advertise
- [ ] Get sign-ups
- [ ] Email details and forms
- [ ] Collect waivers
- [ ] Confirm the visit
- [ ] Confirm transportation, food, and incentive arrangements
- [ ] Provide participants with background information

Introduction to Green Chemistry

What is green chemistry and why is it important?[2]

The concept of greening chemistry is a relatively new idea which developed in the business and regulatory communities as a natural evolution of pollution prevention initiatives. In our efforts to improve crop protection, commercial products, and medicines, we also caused unintended harm to our planet and humans.

By the mid-20th century, some of the long-term negative effects of these advancements could not be ignored. Pollution choked many of the world's waterways and acid rain deteriorated forest health. There were measurable holes in the earth's ozone. Some chemicals in common use were suspected of causing or directly linked to human cancer and other adverse human and environmental health outcomes. Many governments began to regulate the generation and disposal of industrial wastes and emissions. The United States formed the Environmental Protection Agency (EPA) in 1970, which was charged with protecting human and environmental health through setting and enforcing environmental regulations.

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.

We are able to develop chemical processes and earth-friendly products that will prevent pollution in the first place. Through the practice of green chemistry, we can create alternatives to hazardous substances we use as our source materials. We can design chemical processes that reduce waste and reduce demand on diminishing resources. We can employ processes that use smaller amounts of energy. We can do all of this and still maintain economic growth and opportunities while providing affordable products and services to a growing world population.

This is a field open for innovation, new ideas, and revolutionary progress.

[2] http://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html

How is green chemistry different from sustainability?

Many people are familiar with sustainability and environmental friendliness initiatives such as recycling, using less paper, and cleaning up litter and have an awareness of the need to slow global warming, reduce carbon dioxide emissions, etc. It's easy to get these kinds of activities confused with green chemistry because in certain respects they overlap significantly. It is essential, however, to make a distinction between the two.

Although a goal of green chemistry is to create more sustainable practices it's a specific area of the sustainability movement. Green chemistry is a tool for building a sustainable society. For example, recycling plastic is a great sustainability practice. However, a green chemist might consider designing plastic that is more biodegradable, doesn't require petroleum or contain potentially harmful chemicals like BPA, or how to improve the efficiency of the recycling process itself. Another example of a sustainability project would be "going electronic" for a newsletter to reduce paper. A green chemist might consider how to reduce the environmental impact of the paper production process such as eliminating the use of bleach as a whitener or how to re-use chemicals that become waste during the paper production process.

Appendix B: Everyday Examples of Green Chemistry

Here are a number of examples of green chemistry in everyday life. Consider choosing two or three that you find particularly interesting to include on the handout. Of course, there are many more applications, but here a few just to get your thinking cap on:

- *Have you ever had you clothes dry-cleaned?*[3]
    - Dry Cleaning: dry-cleaning processes have conventionally used the chemical perchloroethylene (perc). Several organizations have stated that perc is a hazardous substance to human health. The International Agency for Research on Cancer (IARC) concluded that perc is a "probable human carcinogen" meaning it is likely to cause cancer in addition to its short term effects like dermatitis. Workers in a dry-cleaning facility can be exposed to perc in a number of ways from cleaning the machine to simply loading clothing.[4] In addition, perc is categorized as a hazardous air pollutant by the U.S. EPA's Clean Air Act and it may contaminate groundwater when it is disposed.[5]
    - *Applying green chemistry to this situation has resulted in a markedly improved process using liquid carbon dioxide – a substance that is essentially non-toxic and is equally effective at removing grease and dirt from fabric. This simple innovation of replacing a hazardous chemical for a benign one is a perfect example of green chemistry at work in everyday life.*
- *Do you own something involving a computer chip?*
    - Have you ever considered what goes into making a smartphone, computer, or television work? As technology progresses so does our consumption of endangered elements: the 44 critical materials which will soon face supply limitations. These limitations can stem from factors such as geographic concentration, political motivations, regulatory laws, or consumer demand. Some green chemists are researching more abundant alternatives, more efficient syntheses where alternatives are not found, diversifying the supply and better recycling and recovery programs for these scarce materials. A smartphone, for example, usually contains over 80 elements, many of which are considered "endangered," for everything from the touch screen (dysprosium, europium, etc.) to the color display (yttrium, terbium, and more). To manufacture computer chips, many chemicals, large amounts of water, and energy are required. In a study conducted in 2003, the industrial estimate of chemicals and fossil fuels required to make a computer chip was a 630:1 ratio! That means it takes 630 times the weight of the chip in source

[3] Ryan, M. (ed.), Tinnesand, M. (ed.) (2002*) Introduction to Green Chemistry*, American Chemical Society: U.S.A. pp.23-29
[4] https://www.osha.gov/dsg/guidance/perc.html
[5] http://yosemite.epa.gov/opa/admpress.nsf/0/e99fd55271ce029f852579a000624956

materials just to make one chip! Compare that to the 2:1 ratio for the manufacture of an automobile. This is an example of very poor atom economy. Scientists at the Los Alamos National Laboratory have developed a process that uses supercritical carbon dioxide in one of the steps of chip preparation, and it significantly reduces the quantities of chemicals, energy, and water needed to produce chips. Richard Wool, director of the Affordable Composites from Renewable Sources (ACRES) program at the University of Delaware, found a way to use chicken feathers to make computer chips! The protein, keratin, in the feathers was used to make a fiber form that is both light and tough enough to withstand mechanical and thermal stresses. The result is feather-based printed circuit board that actually works at twice the speed of traditional circuit boards. Although this technology is still in the works for commercial purposes, the research has led to other uses of feathers as source material, including for biofuel.

- *Who owns clothes? By the looks of it, all of you!*
    - Micro-organisms are everywhere, even in our clothes. They cause odors, wearing, and color changes to fabrics in textiles. To reduce the number and effects of micro-organisms on our clothes, antimicrobial textiles have been developed. Unfortunately, some of these synthetic agents have toxic effects on humans. For example, silver antimicrobial agents have caused dermatitis, some synthetic dyes have been found to cause cancer, and still others like zinc pyrithione are mildly neurotoxic. Not only are these compounds harmful to humans, they are often not biodegradable and the waste created by their manufacture is difficult to treat and sometimes become ineffective over time. *Green chemistry approaches have created benign antimicrobial textile solutions. These include materials called biopolymers that are made from a huge variety of renewable materials found in nature such as chitosan from crustaceans and fungi, cyclodextrin from starch, and alginate from brown sea weeds. Antimicrobial agents made from these ingredients are less harmful to the environment, have lower toxicity, are renewable, and still highly functional.* [6]
- *Have you ever eaten food?*
    - Many people are surprised to learn that even what they eat is a product of chemical design. Decaffeination and the production of flavors are just two examples of food-industry processes that green chemistry principles have been applied to with success. Decaffeination of coffee beans using dichloromethane, a suspected carcinogen, was the accepted process for about 70 years. However, greener methods have been developed and applied on an industrial scale. The Swiss water process and the use of supercritical CO_2 are both the result of green chemical innovation. The Swiss water process uses water, green bean extract and a difference of caffeine concentrations. No harmful solvents are used and very little waste is produced as the water is easily recycled. Decaffeination by supercritical CO_2 is also a safer and more environmentally friendly method because it is a very low-waste process using a relatively non-toxic substance; the

[6] Shahid-ul-Islam, Shahid, M., Mohammad, F. Green chemistry approaches to develop antimicrobial textiles based on sustainable biopolymers – a review. *Ind. Eng. Chem. Res.* 2013, 52, 5245-5260.

carbon dioxide is recycled throughout the process and the caffeine solution produced is sold to other manufacturers.[7]

- Consider everything vanilla-flavored you've ever eaten or vanilla-scented candles, soaps, and more that you've used. The production of synthetic vanillin, the main flavor component of natural vanilla extract, has undergone several changes through industry attempts to improve efficiency, reduce waste, and increase the quality as demand grows at a faster rate than vanilla bean production. In the 1930's, use ligninsulfonates (organic material from wood pulp production) became the conventional starting material for vanillin production but were eventually replaced by a petrochemical starting material due to the large amounts of waste created through the wood-production by-product process[8]. New research has found that vanillin molecules can be collected and purified using ionic solvents which are often greener than the solvents they replace (less volatile) and can be derived from renewable resources unlike petrochemicals[9]. Although this synthesis is still in development the pathway towards greener production is being paved.

- *Have you ever used plastic?*
  - Several companies have been working to develop plastics that are made from renewable, biodegradable sources.
  - NatureWorks of Minnetonka, Minnesota, makes food containers from a polymer called polylactic acid branded as Ingeo. The scientists at NatureWorks discovered a method where microorganisms convert cornstarch into a resin that is just as strong as the rigid petroleum-based plastic currently used for containers such as water bottles and yogurt pots. The company is working toward sourcing the raw material from agricultural waste.
  - BASF developed a compostable polyester film that called "Ecoflex®." They are making and marketing fully biodegradable bags, "Ecovio®,"made of this film along with cassava starch and calcium carbonate. Certified by the Biodegradable Products Institute, the bags completely disintegrate into water, CO_2, and biomass in industrial composting systems. The bags are tear-resistant, puncture-resistant, waterproof, printable and elastic. Using these bags in the place of conventional plastic bags, kitchen and yard waste will quickly degrade in municipal composting systems.
- *Have you ever taken a medication?*
  - Merck and Codexis developed a second-generation green synthesis of sitagliptin, the active ingredient in Januvia™, a treatment for type 2 diabetes. This collaboration lead to an enzymatic process that reduces waste, improves yield and safety, and eliminates the need for a metal catalyst. Early research suggests that the new biocatalysts will be useful in manufacturing other drugs as well.

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[7] Jimenez-Gonzalez, C., Constable, D. J. C. (2011) *Green Chemistry and Engineering: A Practical Design Approach.* Hoboken, New Jersey: John Wiley & Sons, Inc.

[8] Calvo-Flores, F.G., Dobado, J.A. Lignin as a renewable raw material, *Chem Sus Chem.,* 2010, 3, 1227-1235. http://onlinelibrary.wiley.com/enhanced/doi/10.1002/cssc.201000157/

[9] http://www.sciencedirect.com/science/article/pii/S1383586610002789

- Originally sold under the brand name Zocor®, the drug, Simvastatin, is a leading prescription for treating high cholesterol. The traditional multistep method to make this medication used large amounts of hazardous reagents and produced a large amount of toxic waste in the process. Professor Yi Tang, of the University of California, created a synthesis using an engineered enzyme and a low-cost feedstock. Codexis, a biocatalysis company, optimized both the enzyme and the chemical process. The result greatly reduces hazard and waste, is cost-effective, and meets the needs of customers.

- *Have you ever painted something?*
  - Oil-based "alkyd" paints give off large amounts of volatile organic compounds (VOCs). These volatile compounds evaporate from the paint as it dries and cures and many have one or more environmental impacts.
  - Procter & Gamble and Cook Composites and Polymers created a mixture of soya oil and sugar that replaces fossil-fuel-derived paint resins and solvents, cutting hazardous volatiles by 50 percent. Chempol® MPS paint formulations use these biobased Sefose® oils to replace petroleum-based solvents and create paint that is safer to use and produces less toxic waste.
  - Sherwin-Williams developed water-based acrylic alkyd paints with low VOCs that can be made from recycled soda bottle plastic (PET), acrylics, and soybean oil. These paints combine the performance benefits of alkyds and low VOC content of acrylics. In 2010, Sherwin-Williams manufactured enough of these new paints to eliminate over 800,000 pounds, or 362,874 kilograms of VOCs.

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