ACS Student Chapter Activity: Getting Green in the Media

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This guide is produced by the ACS Green Chemistry Institute®
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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 chemists

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

Green chemistry is pretty exciting but climbing to the roof of your science building and shouting to the world about it may not be the most effective form of communication. School or community newsletters and magazines are a great way to inform an audience in a conventional format. Now, of course, social media can be used to reach the eyes and ears of an audience of your choice. It's easy to create a publication and even easier to get in on one that's already circulating. This document provides tips on how to spread the word through....words.

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The Art of Information: Where to Start

It might seem like a daunting task at first but there are a few basic decisions that can be made by your student chapter from the get-go that will provide a framework. Once the format is created, ideas are generated, and responsibilities are divided the hard part is done. This section answers some fundamental questions to help your chapter put its thinking caps on.

What are you going to talk about?

First thing's first: members of your student chapter should have a meeting to discuss what topics should be covered. Remember, this is for green *chemistry,* which it is important to distinguish from sustainability and environmental friendliness. So what's the difference?

Initiatives such as recycling, using less paper, and cleaning up litter are examples of general sustainability projects which are focused on the need to slow global warming, reduce carbon dioxide emissions, etc. many of which have been popularized and there's a good level of awareness surrounding them. 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.

The manufacture of goods – everything from cars to paint to pesticides – involves chemical processes. "Green Chemistry" was developed as a way to re-thinking past and current processes, many of which posed significant risk to human health and safety or the environment. Green Chemistry takes into consideration the effects of a chemical through its entire "life" from the time it is extracted from the earth to what happens after it is disposed of as waste. This includes the risks involved in its transportation, effects when it enters wastewater, and potential harm caused to those who are working with it. Green chemistry is also a way in which businesses can reduce their expenses by spending less money on waste treatment and using fewer chemicals in general. Some green chemists consider there to be twelve guiding principles for greener chemistry while others feel the scope is much broader. A few key ideas in green chemistry are to prevent waste instead of treating or cleaning it, use as few materials as possible, make and use non-toxic substances, reduce energy use, take advantage of renewable materials, and design things to be harmless even when they reach the end of their useful life.

Although a goal of green chemistry is to create more sustainable practices it's a specific area of the sustainability movement. For example, recycling plastic is a great sustainability practice. However, a green chemist might consider designing plastic that is more biodegradable, doesn't require non-renewable 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.

In addition, there are lots of options as to what your purpose is: to inform, persuade, teach? The final product will look a little different depending on what direction you're coming from.

Who is the intended audience?

This is the second most important consideration: all of the material you and your chapter produce will be influenced by who you'd like to be reading it. A departmental newsletter circulated among chemistry students and faculty, for example, can include more technical details while a campus-wide newspaper should cover basic background information before diving into a topic. Consider how the intended audience will perceive information on green chemistry, particularly at first. Chemistry faculty might be curious about something new in their field while the average student may glance at an article about chemistry and move on without interest. Just as everyone has different tastes in food and television, not everyone will get excited about the same subjects or stories as you or your student chapter. Keep in mind that media is not for those who create it.

Will the presence be in print, online, or on the air?

Once an intended audience has been chosen, it's time to think about the best way to reach out. There are a variety of communication formats from print newsletters, newspapers, and magazines and even more potential online formats from Facebook pages to YouTube channels. Ask questions based on the needs of the target audience such as:

1) *"Will faculty be interested in following a Twitter feed?"*
2) *"Are students already bombarded with too many emails?"*
3) *"Are the issues addressed relevant to this community?"*
4) *"Is the time of broadcast convenient for potential listeners?"*

A print resource might not be consistent with your message. Readers who perceive a wasteful publication process may not take the content seriously. If you're starting an independent newsletter consider carefully the resources you're using to create it whether that means using recycled paper or going electronic.

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What is the existing media infrastructure (on campus or in the community)?

Many colleges and universities have....

- a print newspaper, newsletter or magazine
  - It's easy to email the editor and request a space for your student chapter to write a column
  - Some universities have newsletters specifically for science topics - there's nothing to stop your group from submitting articles in more than one place.
  - If the green chemistry publication is to be included in a larger body of information, such as an existing newspaper, the amount of effort needed to publicize it will be greatly reduced. If you've presented the idea for a column or article and it has been accepted that means that editor feels that contributions by your student chapter will attract additional readers. Therefore, they'll probably highlight the new topic without too much pressure on your end. Of course, asking if special attention will be paid to a new green chemistry section is only an email away.

- a blog
  - Students or organizations are typically able to request to establish a web page within the umbrella domain. Email your school's IT department and they should be able to help out.
- a radio station or television channel
  - At the beginning of the academic year, such as at a freshman fair, university or student-organized radio stations or television channels will be looking for new programs. If this is something your chapter is interested in, create an outline for a program to build a case for how and why your group will get people to tune in. Creativity is key.

How often will it be produced/updated?

- If the medium is part of a larger publication, the frequency of publication will be predetermined.
- Vlogs and blogs should be updated weekly or bimonthly.
- Facebook, Twitter, and similar social media initiatives should be updated at least once a day. Emphasis on at least. If the whole student chapter is participating, this shouldn't be a problem (more details later in this document).
- Newsletters are typically more extensive. One publication a month is sufficient.
- Make a calendar within your student chapter of future topics so contributors can plan appropriately and there's no pressure each week or month to come up with new ideas. A single brainstorming session with a little research at the beginning of the semester can result in enough material to last the full term.

Will it be "ghost written" by the ACS Student Chapter or will articles be attributed to specific members?

- Everyone knows tensions can rise when it comes to distribution and accreditation of work. Make sure it's clear among members of your student chapter what their responsibilities are, whether that means research, deadlines, editing, etc. If someone has done the majority of the work for something, they deserve credit.
- Encourage the team to communicate with each other as early as possible if they need help or feel like an assignment is too much on top of an already busy schedule or academic workload.
- Divide responsibility between members of your student chapter who are dedicated to finding and sharing material. This makes the project easier to manage which will ultimately result in better quality and consistency.
- Schedule regular meetings to brainstorm, check in with contributors, and discuss where you have and have not had success.

What's the Best Place to Find Credible Information?

As with any subject there is bias among resources in chemistry. It's important to reference reliable sources in order to build the audience's confidence in your knowledge and credibility.

Keep an open mind when searching for answers. Consider viewpoints that oppose yours, whether or not they make claims based on evidence, what organization has sponsored the research, and draw conclusions only after a review of a variety of credible sources.

The best places to find information are **peer-reviewed scientific journals**. Your university or college library almost certainly provides free access to these articles. Email or visit your librarian if you're not sure how to get access (either online or in print). Google Scholar is also a good place to keyword search on the subject of interest.

There are a growing number of green chemistry **textbooks and lab manuals**. Again, your university or departmental library may have copies of these. Otherwise, you can always kindly request that the library order reference copies for chemistry students. A list of these textbooks can be found on the ACS Green Chemistry Institute website, here.

More and more **websites and databases** with information about green chemistry are popping up on the internet. For example, the Greener Education Materials for Chemists (GEMs) database provides a collection of green chemistry resources. The Nexus Blog from the Green Chemistry Institute is another source of articles and information on emerging science. The Washington State Department of Ecology has also put together a list of various online green chemistry resources. The U.S. Environmental Protection agency website has information about many regulations and policy initiatives.

A member of faculty in the chemistry department might be interested in green chemistry. Ask your chapter's advisor and inquire about current research at your university.

Be sure to **reference all materials** used when generating media just as you would for a research paper even if you only expect the publication to circulate within campus.

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How Will You Get People Interested?

Consider this: according to www.stateofthemedia.org 93% of all Americans still tune into their local radio station at least once a week and the world's leading daily newspaper, *The Wall Street Journal*, continues to be circulated to nearly 2.4 million people *every day*.

Perhaps the most important thing to keep in mind is **that building a presence takes time and consistency**. Note that while the *Wall Street Journal* has a huge number of subscribers, it's also been gaining a following for 125 years. Get to know your audience and what they like. This can be as simple as asking your friends what they think and what they'd be interested in hearing more about.

Stay responsive and construct your communication as a forum for conversation rather than an advertisement. Answer questions, reply to comments, and ask readers, subscribers, viewers and listeners what they like and dislike.

As with any kind of writing you want to be better at, read it. The same idea follows for hosting a show or making a vlog**. Read, watch, listen: write, create, record.** Try to notice themes in structure and organization, tone, visuals, etc. in existing publications. Here are few of the most popular science news and education (not green chemistry-specific) resources to start poking around for inspiration (and don't focus on the fancy websites or graphics, of course many of these organizations have *way* bigger budgets!):

News

- *Popular Science*
- *BBC Science and Environment*
- *Chemical and Engineering News*
- *Phys.org*

Social Media

- @nieldegrassetyson (Twitter)
- @NASA (Twitter)
- NASA's blog
- I F****ing Love Science for Blog, Tweet, and Facebook post inspiration

Online Videos

- Crash Course
- Minute Physics
- SciShow

TV/Radio Shows/Podcasts

- *Popular Science's* Recommended Listening
- and a few more broadcasts recommended by *The Telegraph*

Submitting Your Green Student Chapter Activity

Once your ACS student chapter has completed a green activity it's time to fill out the student report with details about what's been done. Feel free to send along photographs or a mention of your work in the university or college news.

See this webpage for information on deadlines, submission requirements, and the report form.

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Want to Know More about Green Chemistry?

If you're feeling unsure about what green chemistry is, how it applies to you, or why it's worth writing an article, below are some examples of green chemistry in everyday life and resources where you can become familiar with the basic concepts.

Websites:

The ACS Green Chemistry Institute
Beyond Benign
The Berkeley Center for Green Chemistry
Green Chemistry Initiative at the University of Toronto

A list of textbooks and lab manuals with a green chemistry focus can be found here.

Everyday Examples of Green Chemistry [2]

Below are some interesting examples of how green chemistry affects everyone.

- *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

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

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 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-

[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.

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 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,

[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

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.
    - 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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