

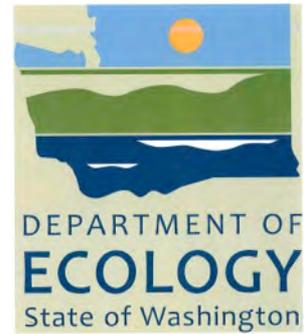
Green Chemistry Webinar Series for HS Teachers:

Introducing Green Chemistry into the High School

10/2/13

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Wilmington, MA

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- Visit the WA State Dept of Ecology Green Chemistry pages:

www.ecy.wa.gov/programs/hwtr/P2/greenchem_ecy.html

www.ecy.wa.gov/programs/hwtr/P2/greenchem_resources.html

- Participate by asking questions during the webinar and providing feedback with the follow-up survey
- WA State teachers will receive 3 clock hours for attending & participating in all three webinars.
Please contact:

Saskia van Bergen Saskia.vanBergen@ecy.wa.gov

MISSION AND VISION

Beyond Benign is dedicated to providing future and current scientists, educators and citizens with the tools to teach and learn about green chemistry in order to create a sustainable future.

Beyond Benign's vision is to revolutionize the way chemistry is taught to better prepare students to engage with their world while connecting chemistry, human health and the environment.

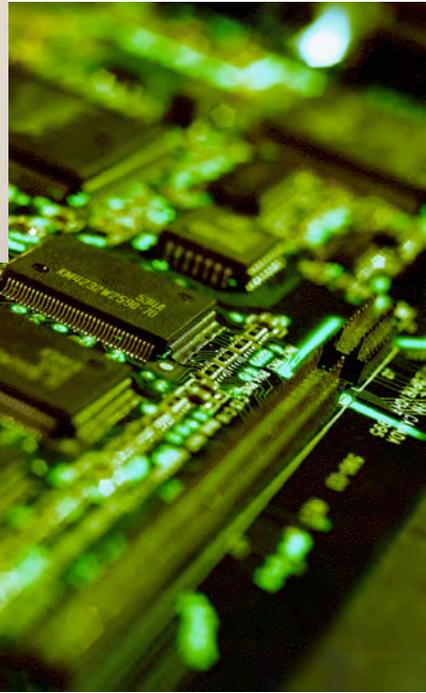


Green Chemistry is

“the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the **design**, manufacture and application of chemical products”

- The science of making things
- The science of innovation & invention
- The science of **solutions**





Formaldehyde

Polybrominated
diphenylethers (PBDEs)



Bisphenol A (BPA)

The Assessment of Risk

$$\text{Risk} = \text{Exposure} \times \text{Hazard}$$



Chemists have *ALWAYS* cared about Human Health and the Environment.



$$\text{Risk} = \text{Exposure} \times \text{Hazard}$$

Green Chemistry is the only science where the focus is reducing and/or eliminating the intrinsic hazards.

Chemists and materials scientists have the greatest potential to impact pollution prevention.



How does Green Chemistry fit
into the bigger picture of
“Sustainability”?

Sustainability

Economics Agriculture Education Business Chemistry Engineering Others

Sustainable Chemistry

Chemicals Policy Remediation Technologies Exposure Controls Green Chemistry Water Purification Alternative Energy Others

Green Chemistry

Solvents Catalysts Renewable Feedstocks Reduced Toxicity Non Persistent Reduced Energy Others

Sustainability

Economics Agriculture Education Business Chemistry Engineering Others

Sustainable Chemistry

Chemicals Remediation Exposure Green Water Alternative Others
Policy Technologies Controls Chemistry Purification Energy

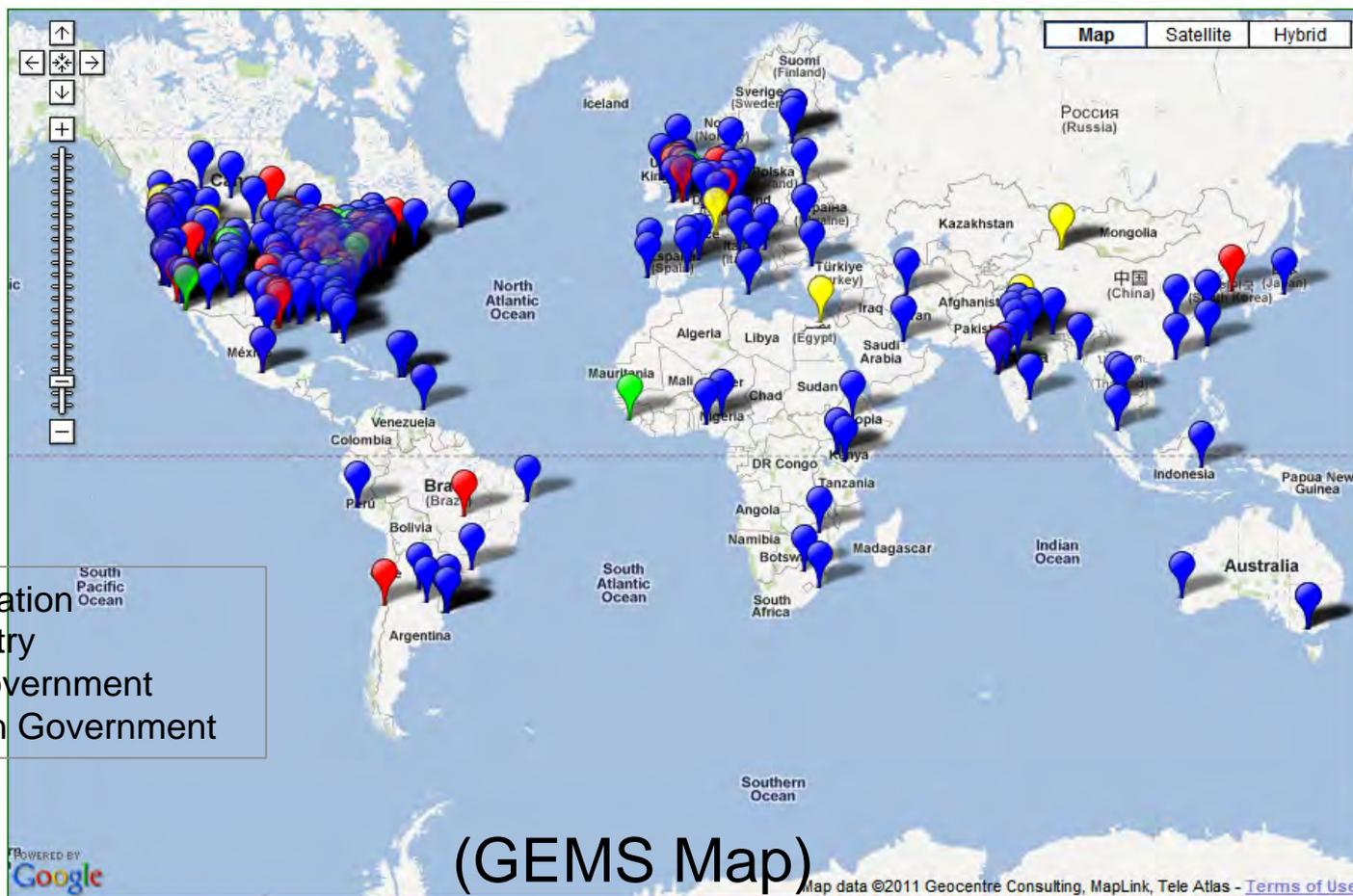
Green Chemistry

1 2 3 4 5 6 7 8 9 10 11 12

The Twelve Principles of Green Chemistry

- 1. Prevention.** It is better to prevent waste than to treat or clean up waste after it is formed.
- 2. Atom Economy.** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- 3. Less Hazardous Chemical Synthesis.** Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
- 4. Designing Safer Chemicals.** Chemical products should be designed to preserve efficacy of the function while reducing toxicity.
- 5. Safer Solvents and Auxiliaries.** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous.
- 6. Design for Energy Efficiency.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
- 7. Use of Renewable Feedstocks.** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical.
- 8. Reduce Derivatives.** Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible .
- 9. Catalysis.** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- 10. Design for Degradation.** Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.
- 11. Real-time Analysis for Pollution Prevention.** Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
- 12. Inherently Safer Chemistry for Accident Prevention.** Substance and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

Green Chemistry Around the World

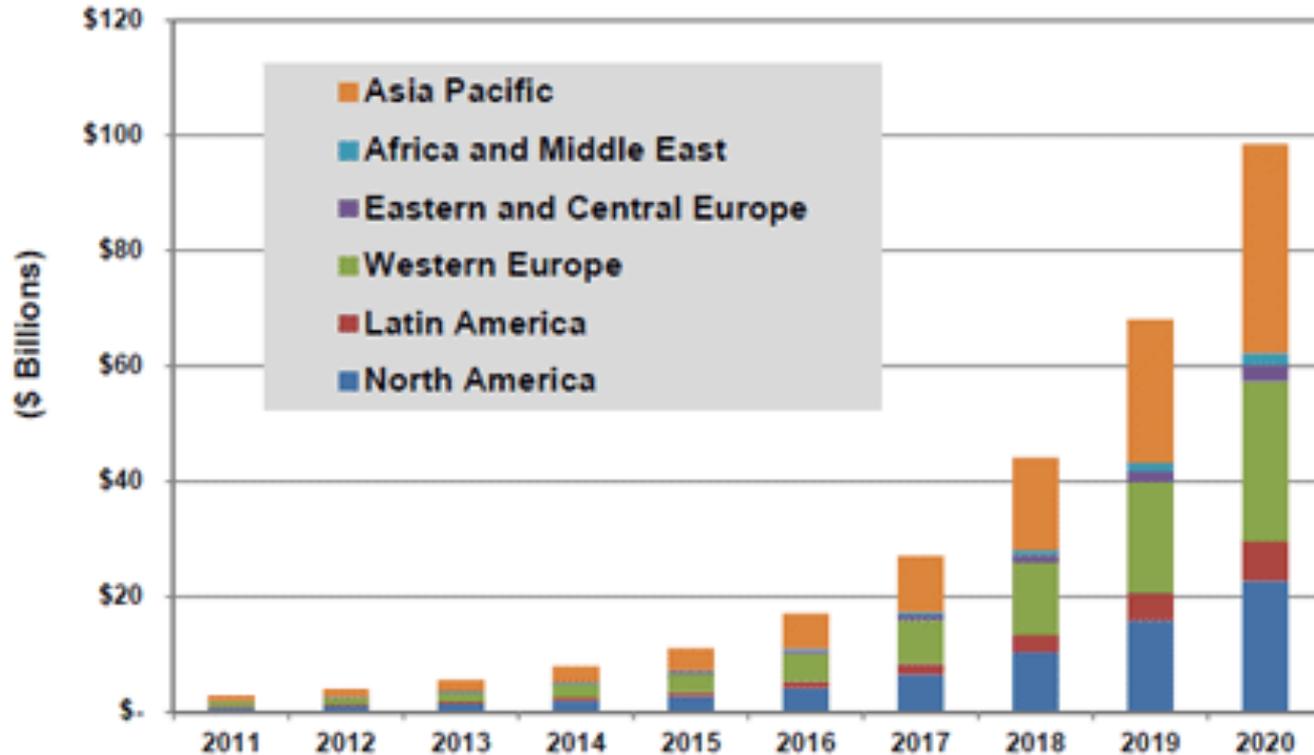


<http://greenchem.uoregon.edu/Pages/MapDisplay.php>



Green Chemistry Market Growth = Job Opportunities for Students

Chart 1.1 Green Chemical Market by Region, World Markets: 2011-2020



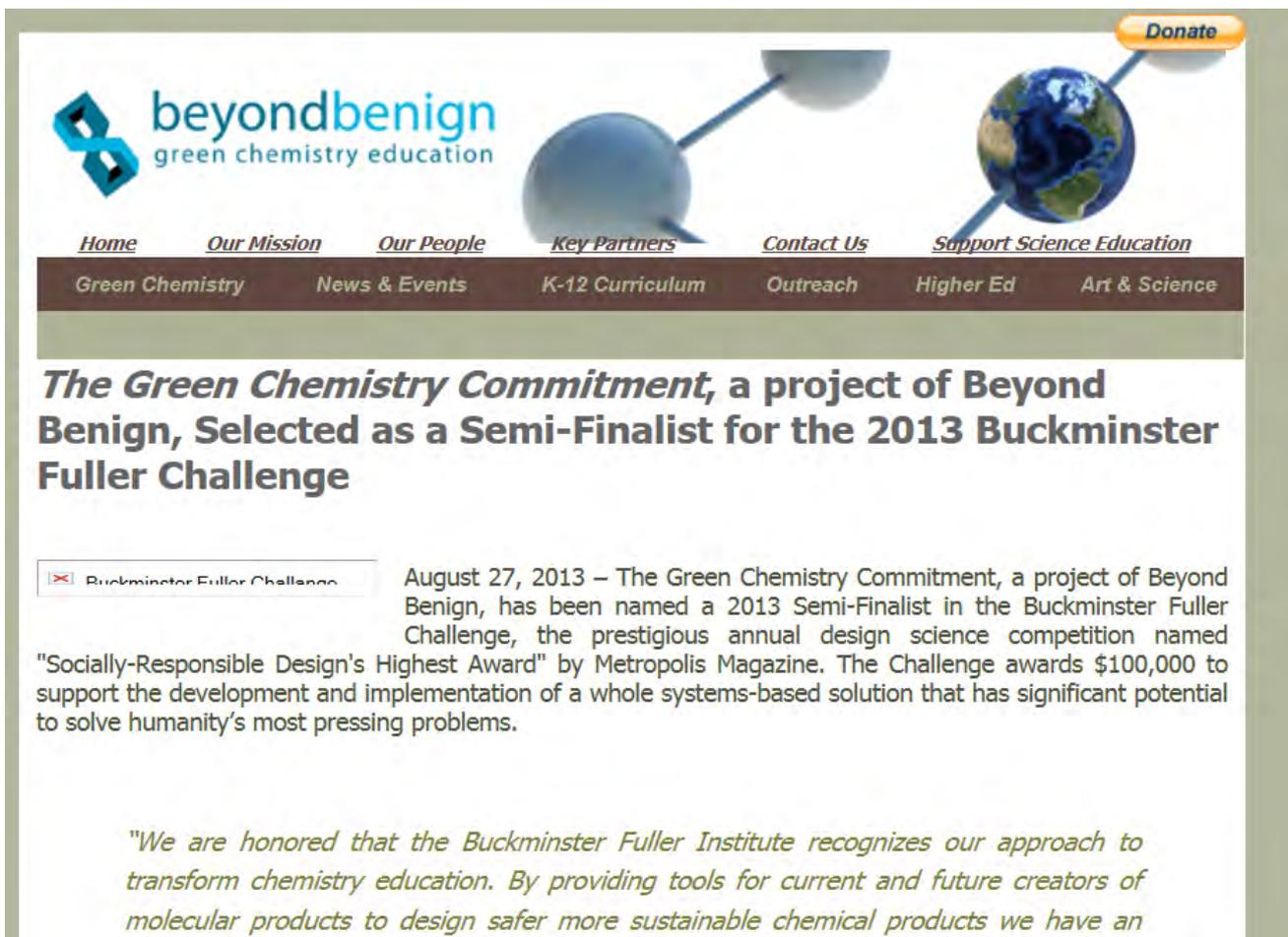
(Source: Pike Research)

Green Chemistry as a teaching tool



Website

www.beyondbenign.org



The screenshot shows the website header for Beyond Benign, featuring the logo (a blue infinity symbol) and the text "beyondbenign green chemistry education". A navigation menu includes links for Home, Our Mission, Our People, Key Partners, Contact Us, and Support Science Education. A "Donate" button is located in the top right corner. Below the navigation menu, a dark brown bar contains sub-links: Green Chemistry, News & Events, K-12 Curriculum, Outreach, Higher Ed, and Art & Science. The main content area features a headline: "The Green Chemistry Commitment, a project of Beyond Benign, Selected as a Semi-Finalist for the 2013 Buckminster Fuller Challenge". Below this is a news item with a small image placeholder and the text: "August 27, 2013 – The Green Chemistry Commitment, a project of Beyond Benign, has been named a 2013 Semi-Finalist in the Buckminster Fuller Challenge, the prestigious annual design science competition named 'Socially-Responsible Design's Highest Award' by Metropolis Magazine. The Challenge awards \$100,000 to support the development and implementation of a whole systems-based solution that has significant potential to solve humanity's most pressing problems." At the bottom, there is a quote: "We are honored that the Buckminster Fuller Institute recognizes our approach to transform chemistry education. By providing tools for current and future creators of molecular products to design safer more sustainable chemical products we have an



About our Lessons

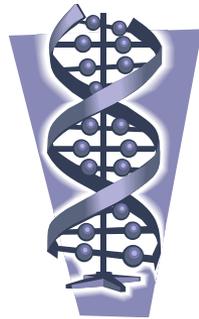
- For teachers by teachers
- Classroom tested
- Contents Include:
 - Teacher Background Information
 - Goals, Learning Objectives, Materials, Standards
 - Teacher Prep, Procedure, Student Handouts
 - Green Chemistry Principles Addressed
 - Supplemental Information

K-12 Curriculum

- Green Chemistry

- »*Solutions in Green Chemistry*

- »*Chemistry with a Conscience*



- Biotechnology & Genetics

- »What's Up with Gena

- »How the Fur Flies

- Math & Green Engineering

- »*ME in Context*

- »*ME in Your Neighborhood*



A molecular model with several blue spheres connected by lines. One of the spheres is replaced by a realistic image of the Earth, symbolizing the connection between chemistry and the environment.

Green Chemistry: High School Level

- **SECTION 1:** What is Green Chemistry?
- **SECTION 2:** Green Chemistry in Industry
- **SECTION 3:** Green Chemistry Replacement Laboratory Exercises

Next Generation of Science Standards

High School

HS-ETS1-3 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-3.Evaluate a **solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

HS-ESS3-2 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-2.Evaluate competing **design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.**



Green Chemistry ties to WA Environmental & Sustainability Standards

Principles of Green Chemistry		Environmental & Sustainability Standards
1	Prevention	
2	Atom Economy	
3	Less Hazardous Chemical Syntheses	Standard 3
4	Designing Safer Chemicals	Standard 1 Standard 2
5	Safer Solvents and Auxiliaries	
6	Design for Energy Efficiency	Standard 1 Standard 2
7	Use of Renewable Feedstocks	Standard 3
8	Reduce Derivatives	
9	Catalysis	
10	Design for Degradation	Standard 1 Standard 3
11	Real-time analysis for Pollution Prevention	
12	Inherently Safer Chemistry for Accident Prevention	

Environmental & Sustainability Standards:

Standard 1: Ecological, Social, and Economic Systems

Students develop knowledge of the interconnections and interdependency of ecological, social, and economic systems. They demonstrate understanding of how the health of these systems determines the sustainability of natural and human communities at local, regional, national, and global levels.

Standard 2: The Natural and Built Environment

Students engage in inquiry and systems thinking and use information gained through learning experiences in, about, and for the environment to understand the structure, components, and processes of natural and human-built environments.

Standard 3: Sustainability and Civic Responsibility

Students develop and apply the knowledge, perspective, vision, skills, and habits of mind necessary to make personal and collective decisions and take actions that promote sustainability.

Thinking Green while teaching Chemistry

Skyline High School

Ann Arbor, Michigan

Kathe Blue Hetter

Science Curriculum Lead Teacher



How we got started

- New High School - opened Sept. 2008
- LEED certified building
 - Geothermal heating/cooling
 - Recycled materials
 - Solar passive lighting
 - Wind Turbine



Our Science Department's Mission

- To develop a Sustainable/Green Chemistry course for all students to take.
 - S/G Chemistry 1 - all tenth graders
 - S/G Chemistry 2 - 11th grade course
- Goals
 - Raise student's awareness of Green Chemistry and its 12 Principles.
 - As a department we strive to adhere to these principles when designing experiments.

What does Green Chemistry mean at Skyline?

- Preventing Pollution
 - Using chemicals that do not harm either our health or the environment.
 - Using industrial processes that reduce or eliminate hazardous chemicals.
- Using less energy
 - Designing more efficient labs that minimize the product of waste materials and decreases the amount of non-renewable energy.
- Incorporating Green technology and educating our students to the three E's when conducting investigations.
 - Social Equity
 - Economics
 - Environment

Introductory Activities

- Opinions Activity
 - Done first day of class
 - Great activity to do outside with students.
 - Have students trade answer sheets and try to explain why that person gave their answer.

Second Day of Class

- Defining Sustainability
 - Students are asked to brainstorm what they would like to see last beyond their lifetime.
 - Break it down into the Three E' s
 - Environment
 - Social Equity
 - Economics

Day 3: Synonyms Simplify

- Activity starts with common sayings and turning them into scientific terminology.
- Example: Homo sapiens who reside in vitreous domiciles should not launch geological pieces.
- Students in groups are assigned one of the 12 principles and they simplify it.
- Each group makes a poster of these which are displayed all year.

More Introductory Activities

- Writing the Principles
 - Making Lemonade using lots of unnecessary ingredients.
 - Students write in their journals what is necessary and what could be changed.
- E-Factor Environmental Impact Factor
- Using M & M' s where green ones are the molecules that we want and every other color is waste.
- Lifecycle and Sustainability Analysis
 - Do this activity to get students to see how Green Chemistry is applied in the real world.

CURRICULUM MAPPING SNAPSHOT

4. Atoms and the periodic table

- “Hydrogel Beads: The New Slime Lab? Science Teacher, summer 2011 volume 78 #5. Page 50. *This lab activity is an inexpensive inquiry activity on chemical bonding, properties, and replacement reactions. Students synthesize a cross-linked polymer hydrogel.*

Available free from the NSTA site if you are a member or you can pay 0.99 cents to get this issue.

http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/4/tst11_078_05_50

5. Nomenclature

- “Chemistry of Cosmetics” Beyond Benign. *Students look at the materials used to make common cosmetics products. They look at the molecular structure of organic compounds and how the shape of the molecule affects the toxicity and potential health hazards that have been associated with cosmetic ingredients. This lesson is particularly relevant for female students and can really help to capture their interest in an effort to get more female students into chemistry.*

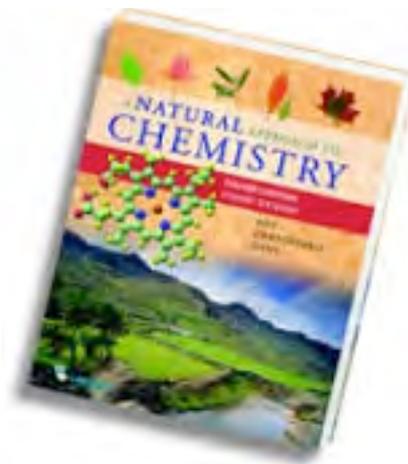
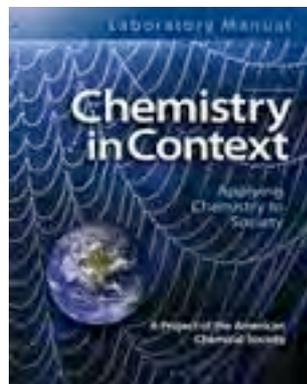
6. Chemical Reactions and Equations

- “Reactions Lab” – Beyond Benign. *In this lesson students observe reactions and identify the type and products produced in those reactions and compare the reactions for their toxicity using the 12 principles of green chemistry.*

www.beyondbenign.org/K12education/hsgc/001%20Curriculum%20mapping.pdf

Helpful Textbooks

- A Natural Approach to Chemistry by Hsu & Chaniotakis (Lab-aids)
- Chemistry in Context: Applying Chemistry to Society
 - Project of the ACS



QUESTIONS



Thank you! Please Join Us Again!

******You must register for all the webinars individually**

October 30, 2013, 3:00 pm - 4:00 pm PST

- **Connecting Chemistry Concepts to Cutting-Edge Science Innovations**

<https://attendee.gotowebinar.com/register/2743974555656922368>

November 13, 2013, 3:00 pm - 4:00 pm PST

- **Safer Chemistry: Drop-In Replacement Labs**

<https://attendee.gotowebinar.com/register/4847586590197116416>

Reminder:

WA State teachers will receive 1 clock hour for attending & participating in this webinar

contact: Saskia van Bergen Saskia.vanBergen@ecy.wa.gov by **10/3/13**