



beyondbenign
a warner babcock foundation

Green Chemistry Education at Beyond Benign

Amy S. Cannon, Ph.D.
Executive Director
Beyond Benign



Beyond Benign promotes science driven by the principles of Green Chemistry in order to create an environmentally, socially and economically prosperous world.

A non-profit created to carry on work in Green Chemistry education in the interdependent areas of K-12, Community, Industry and Government



www.beyondbenign.org



- Headquarters located in Wilmington, MA (~20 minutes north of Boston)
- Employees based in MA, CO and CT; Curriculum specialists nation-wide and international
- Co-founded by John Warner and Amy Cannon in August of 2007
- Created to carry on work in Green Chemistry education in the interdependent areas of K-12, Community, Industry and Government



The Learning Center at Beyond Benign





K-12

- Curriculum Development and Teacher Training
 - Green Chemistry
 - Green Math & Engineering
 - Biotechnology



Community

- K-12 and Community Outreach
 - K-12 classroom visits
 - Community events
 - Informational/promotional events
- Community Building (Regional and International)



Workforce Development

- Curriculum Development and Training
 - Academia
 - Technical Training
 - Green chemistry training for workers
 - iSUSTAIN™ Green Chemistry Index



Art & Science

- Curriculum development and training
- Public art and Exhibits
- Greener media



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Workforce Development

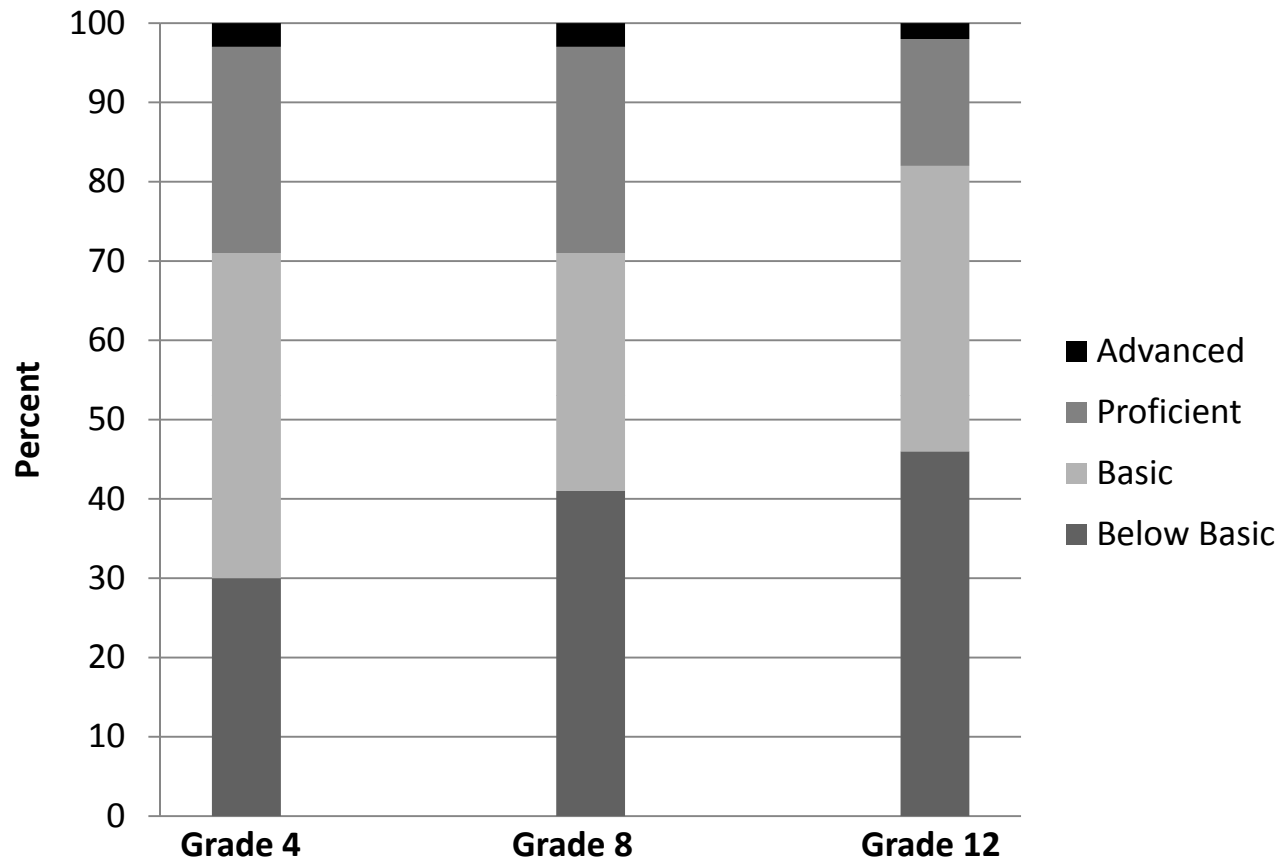
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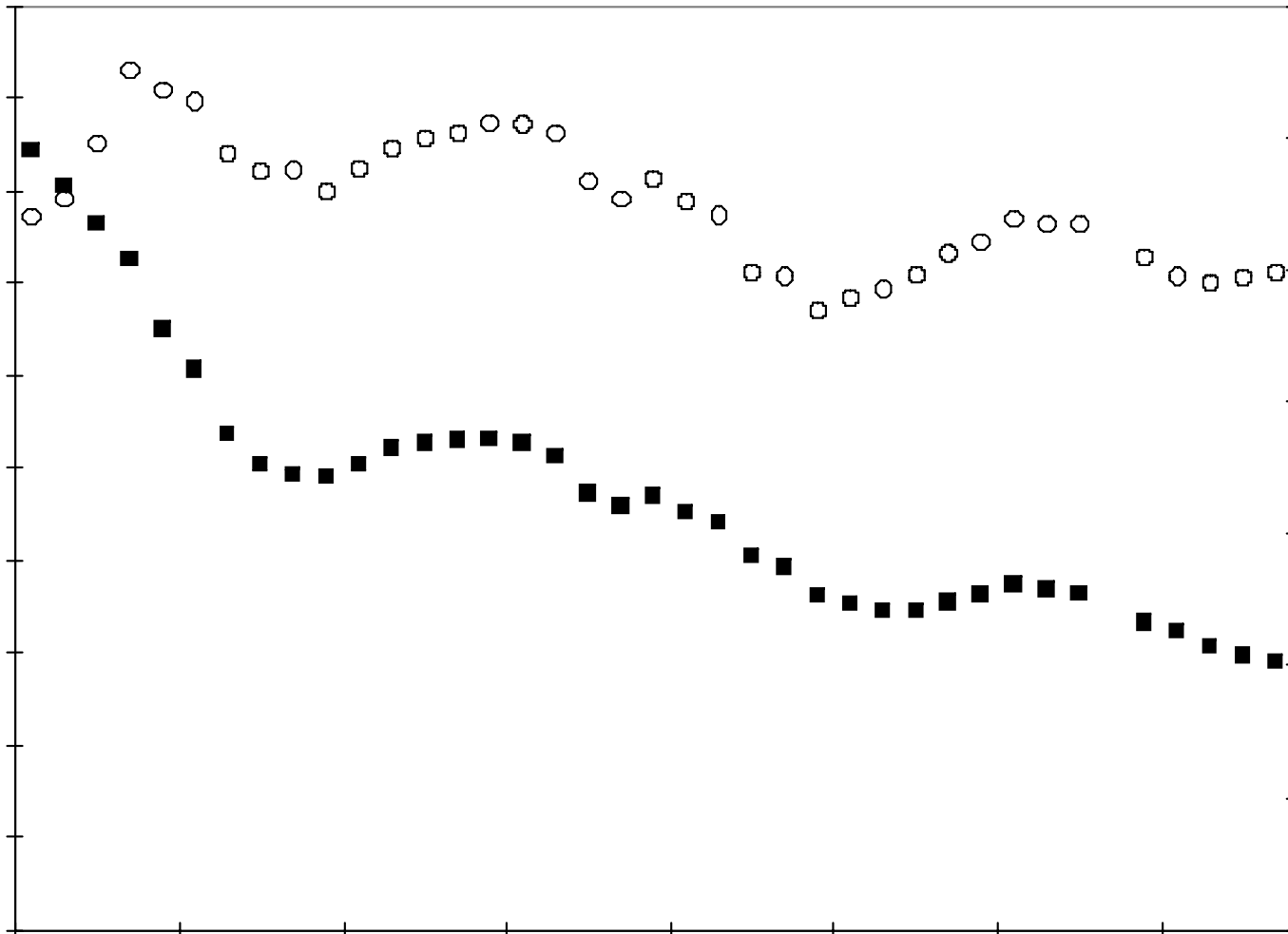
Art & Science

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Why K-12?



Science achievement-level performance reported by:
National Assessment of Educational Progress (NAEP) at the U.S. Department of Education, 2005



The degrees given in the physical sciences in the U.S. from 1966-2004, represented as:
(○) the total number of graduates and (■) the percentage of all bachelor's degrees given,
as reported by the National Science Foundation.

Core Philosophies

- ✓ Teachers teaching teachers
- ✓ Classroom tested teaching materials
 - ✓ Classroom support
 - ✓ Hands-on, inquiry-based activities
- ✓ Science for all in an interdisciplinary format
 - ✓ Open Access education materials
 - ✓ Industry partnerships
 - ✓ Neutrality



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Beyond Benign: K-12 Curriculum and Training

Chemistry with a
Conscience:
The Science of Shampoo



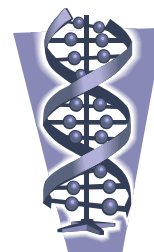
Solutions in
Green Chemistry

ME in your
Neighborhood



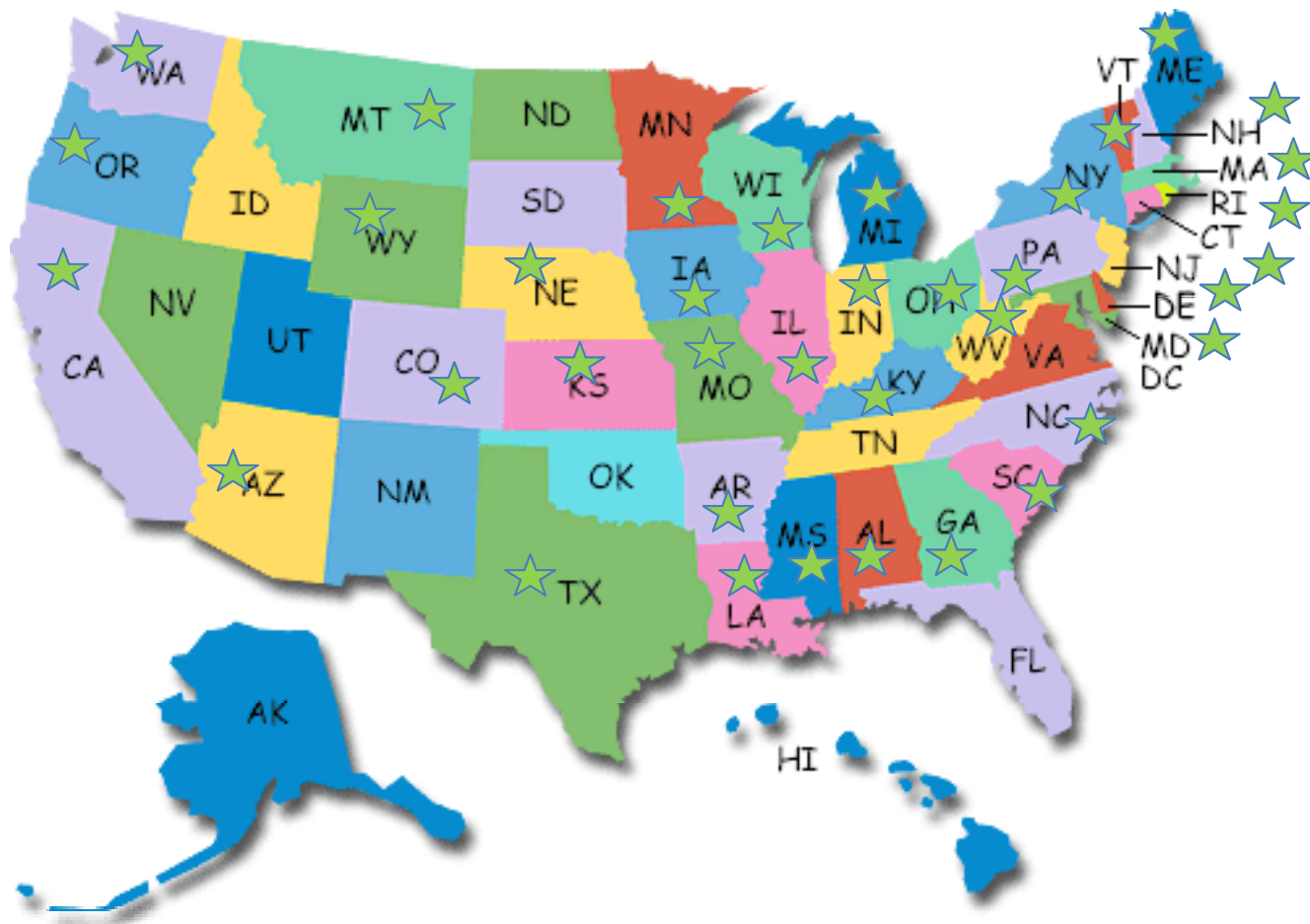
ME in Context

How the Fur Flies



What's Up
with Gena

Continental US



K-12

- Curriculum Development and Teacher Training
- Middle School & High School
 - Green Chemistry
 - Green Math & Engineering
 - Biotechnology

“I came for the donuts,
but I stayed for the science.”



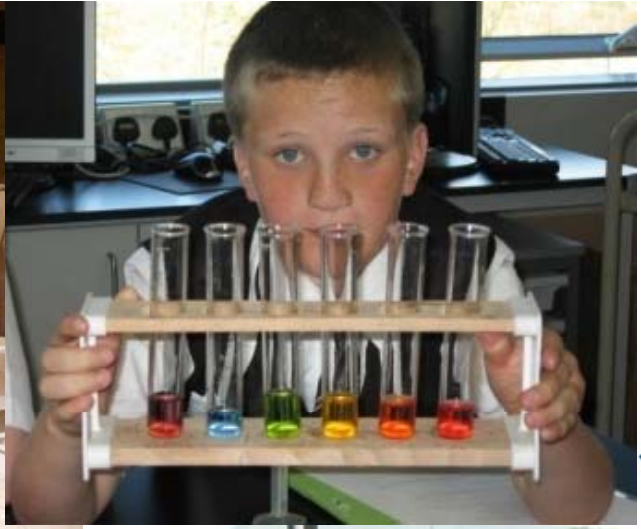
www.beyondbenign.org



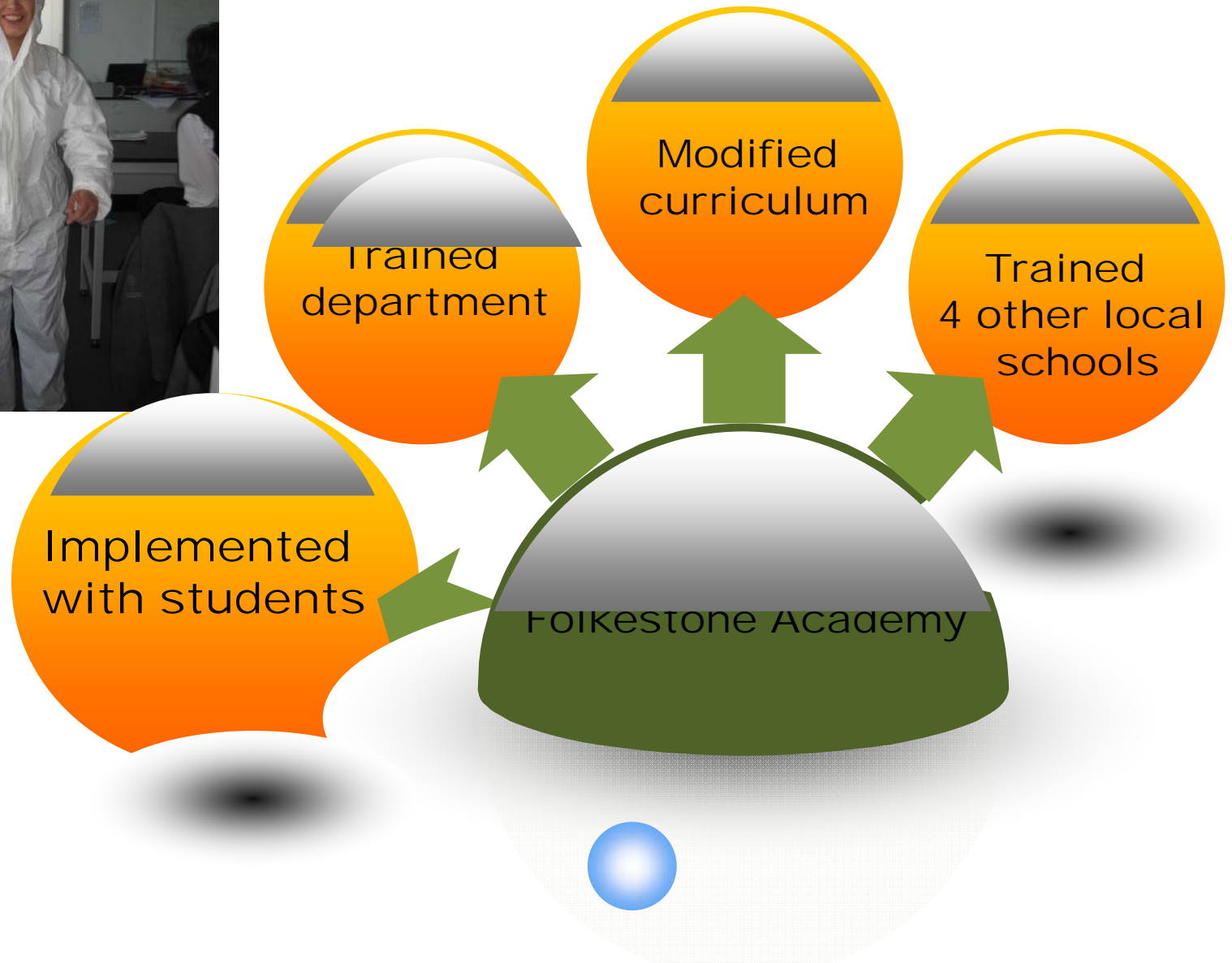
Beyond Benign: The Numbers

United States:	1,233
United Kingdom:	62
Ireland:	90
Puerto Rico:	39
Canada:	67
Australia:	33
Germany:	12
Thailand:	1
Mexico:	5



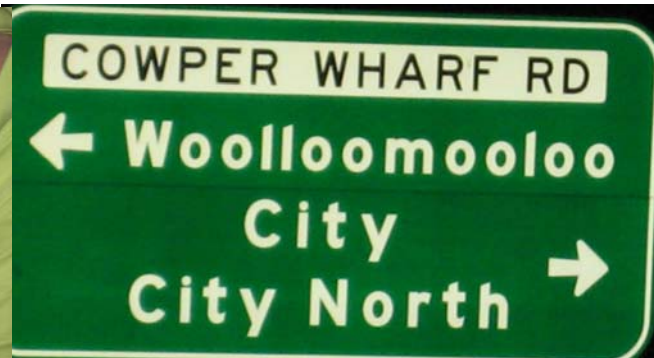


One British teacher



K-12 Curriculum and Training: Next Steps

1. **Continue work abroad & at home**
 - Hand dissemination over to educators abroad
 - Continue presenting workshops in US
2. **Continue to build lessons using 12 principles of green chemistry & 12 principles of green engineering that relate to student lives**
3. **Expand to support community college & university**
4. **Develop an on-line component**





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K-12 and Community Outreach

- Generate excitement for science
- Learn about green chemistry and sustainability
- Instill environmental stewardship and social responsibility as scientists, consumers and inhabitants of earth
- Inspire future scientists



K-12 and Community Outreach

- 3,534 people reached in the past year
- 60 outreach visits in one calendar year
 - 38 school events
 - 16 community events
 - 4 college student events
 - 2 professional development events
- 1,952 school children
- 1,514 community members
- 42 teachers
- 44 outreach fellows

Green Chemistry Outreach Fellows

- Regional undergraduate college science majors
- Over 40 students currently in program
 - Gordon College
 - Simmons College
 - Suffolk University
 - Bridgewater State College
- Participate in outreach
- Project (research or outreach based)
- Exposure to the larger GC community



“If you can’t explain something simply, you don’t understand it well.



Most of the fundamental ideas of science are essentially simple, and may be expressed in a language comprehensible to everyone.”

-Albert Einstein





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Green Chemistry and Regional Economic Development

A company needs:

- Workforce Development/Training
- Resource Use/Management
- Education

To get:

- Community Relations
- Beyond Compliance
- Reduced Liability
- Worker Health & Safety



Green Chemistry and Regional Economic Development

1. Prevention.
 2. Atom Economy.
 3. Less Hazardous Chemical Synthesis.
 4. Designing Safer Chemicals.
 5. Safer Solvents and Auxiliaries.
 6. Design for Energy Efficiency.
 7. Use of Renewable Feedstocks.
 8. Reduce Derivatives.
 9. Catalysis.
 10. Design for Degradation.
 11. Real-time Analysis for Pollution Prevention.
 12. Inherently Safer Chemistry for Accident Prevention.
- Attracting and maintaining companies/industries in a region
 - Using local resources
 - A steady supply of jobs
 - A regional educational network
 - Sustained economic growth

How will Green Chemistry advance throughout the 21st century?

- R&D to Implementation
- Education
 - Teach the next generation of scientists how to design green alternatives
- Tools

Tools

- Curriculum and Training
- Research tools for design
 - Solvent substitution
 - Reagent guides
 - Green Chemistry in Practice guides
 - Hazard/toxicity property guides
 - iSUSTAIN™ Green Chemistry Index



iSUSTAIN™

Green Chemistry Index

Welcome to the iSUSTAIN™ Green Chemistry Index v2.0

Foreword by Dr. John Warner, Director, Warner-Babcock Institute of Green Chemistry -

"Sustainability efforts in institutions across the world have become mainstream and ubiquitous. Although much attention and resources are being spent on such activities, there does not exist a universal understanding of how sustainability can be truly measured and tracked to determine the actual success of any "sustainability endeavor". The iSUSTAIN Sustainability Index provides the user with a CREDIBLE and QUANTIFIABLE assessment of the relative sustainability of a material process."

The iSUSTAIN™ Index is a tool to generate a sustainability-based score for chemical products and processes. It contains a set of sustainability metrics based on the Twelve Principles of Green Chemistry* and takes into account such factors as waste generation, energy usage, health and environmental impact of raw materials and products, safety of processing steps, and others.

The iSUSTAIN™ index is designed to:

- Provide a quantitative measure of the sustainability of products and processes to both develop an initial sustainability baseline and provide guidance for process improvement
- Act as a learning tool for the scientific community to provide increased familiarity with the Twelve Principles of Green chemistry
- Allow use from very early stages in a project's development through to commercialization

A public web-based version of the iSUSTAIN™ Sustainability Index has been developed through an alliance between Cytec Industries Inc., a sustainability-aware specialty chemicals and materials company; Sopheon PLC, a leading provider of stage-gate project development software; and Beyond Benign, the non-profit arm of the Warner-Babcock Institute for Green Chemistry. It is being provided for free and without restriction to any and all potential users.

* Anastas and Warner, Green Chemistry: Theory and Practice, 1998, Oxford University Press

Sign in to iSUSTAIN

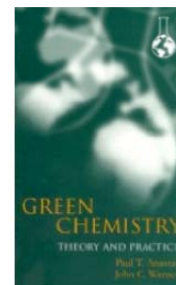
Email

Password

[Sign in](#) or [Register](#)

[Forgot password? Click here](#)

Based on the Book:



**Green Chemistry:
Theory and Practice**

by **Paul T. Anastas** and
John C. Warner

iSUSTAIN is brought to you by:

CYTEC

sopheon
Where innovation means business™



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The Index – Scenarios

Getting Started | **Scenarios** | Data Input | My Profile | Log Out

Scenarios

Isopropyl Lactate (Sample Scenario)

Actions	Scenario Name	Description	Last Modified
	Isopropyl Lactate (Sample Scenario)	Organic Syntheses Collective Volume 2, Pg. 365, John Wiley & Sons, Inc., NY, 1943	3/3/2010
	What-if Scenario A		3/3/2010
	Research Project 123		3/3/2010
	Development Project XYZ		3/3/2010
	Product ABC		3/3/2010

 Add New Scenario  Add Sample Scenario

- To use the **iSUSTAIN™ Index**, the user generates a scenario
- The scenario contains information on
 - The materials going into a process (the BOM In)
 - The materials out of a process (the BOM Out)
 - The conditions used for the various steps in a process (the Process Steps)
- Several alternative scenarios can be generated for the same product/process to see the effect on the overall **sustainability** score

The Index – Metrics

The Twelve Principles of Green Chemistry

1	Waste Prevention	90
2	Atom Economy	90
3	Safe Raw Materials	60
4	Safe Product	75
5	Safe Solvents	80
6	Energy Efficiency	65
7	Renewables	35
8	Process Complexity	60
9	Catalysis	100
10	Biodegradability	0
11	Process Control	80
12	Safe Process	80

- The Index has a metric for each of the Twelve Principles of Green Chemistry
 - Each metric uses the information in the scenario to generate a score
 - All scores are scaled between zero (the lowest) and 100 (the best)
 - These scores quickly point out the areas in most need of improvement
- Information on over 5,400 raw materials is currently provided in the Index Raw Materials database
 - A request to add a raw material not in the database can be made to Beyond Benign

Remember: Sustainability is relative – a process isn't inherently Green, but it can be made Greener

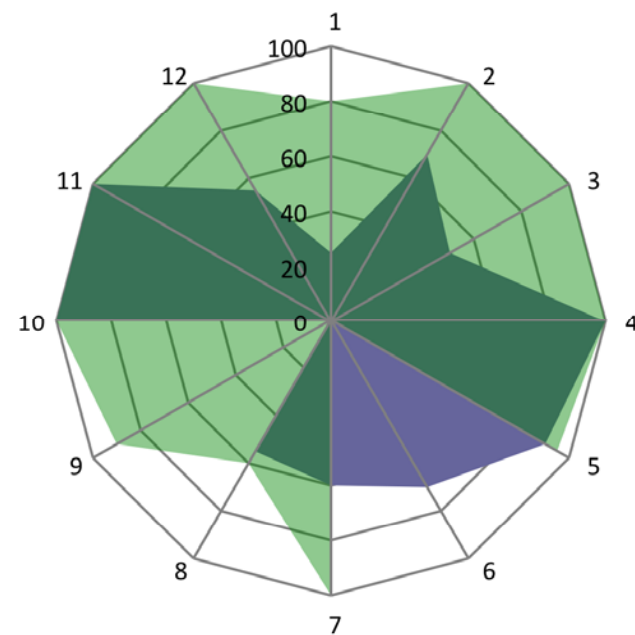
Scenario: Lactic Acid: Chemical Route

Description: Based on actual 7 step chemical route to lactic acid. Some assumptions made: pressure/temperature conditions, % conversion

User: Amy Cannon

Exported: 4/23/2010

	Chemical	Fermentation
1. Waste Prevention	25	80
2. Atom Economy	70	100
3. Safe Raw Materials	50	100
4. Safe Product	100	100
5. Safe Solvents	90	95
6. Energy Efficiency	70	0
7. Renewables	60	100
8. Process Complexity	55	60
9. Catalysis	0	90
10. Biodegradability	100	100
11. Process Control	100	100
12. Safe Process	55	100





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www.isustain.com

