Green Chemistry Education Webinar Series

April 17, 2014

The 12 Principles of Green Chemistry: Sustainability at the Molecular Level

GREEN CHEMISTRY & COMMERCE COUNCIL

Business Mainstreaming Green Chemistry

What is the GC3?

A cross sectoral, B-2-B network of more than 70 companies and other organizations formed in 2005 with a mission to promote green chemistry and design for environment (DfE), nationally and internationally

GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

The 12 Principles of Green Chemistry: Sustainability at the Molecular Level: Speakers

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

John C. Warner, President and Chief Technology Officer, Warner Babcock Institute for Green Chemistry, LLC

GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

Ground Rules

- Due to the number of participants on the Webinar, all lines will be muted.

- If you wish to ask a question or make a comment, please type in the Q&A box located in the drop down control panel at the top of the screen

- Questions will be answered at the end of the presentation.

GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

Upcoming Events

http://www.greenchemistryandcommerce.org/

The Coop Story: How a leading Danish Retailer is working to eliminate endocrine disrupting chemicals from its products, **Wednesday, April 30, 1pm est/10am pst**

And….

9th Annual
GREEN CHEMISTRY & COMMERCE COUNCIL
Innovators Roundtable
MAY 28–30 2014
St. Paul, Minnesota
Hosted by 3M

GREEN CHEMISTRY & COMMERCE COUNCIL

Business Mainstreaming Green Chemistry

THANK YOU!

The 12 Principles of Green Chemistry: Sustainability at the Molecular Level

Amy S. Cannon
Executive Director
Beyond Benign

John C. Warner
President and Chief Technology Officer
Warner Babcock Institute for Green Chemistry, LLC

warnerbabcock
institute for green chemistry

beyondbenign

Disclaimer

Today's Talk:

- Green Chemistry
- Product Design
- Zero and Big Numbers
- How it fits together
- Examples from WBI

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Green Chemistry is the *design* of chemical products and processes that reduce or eliminate the *use and/or generation* of hazardous substances.

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 .

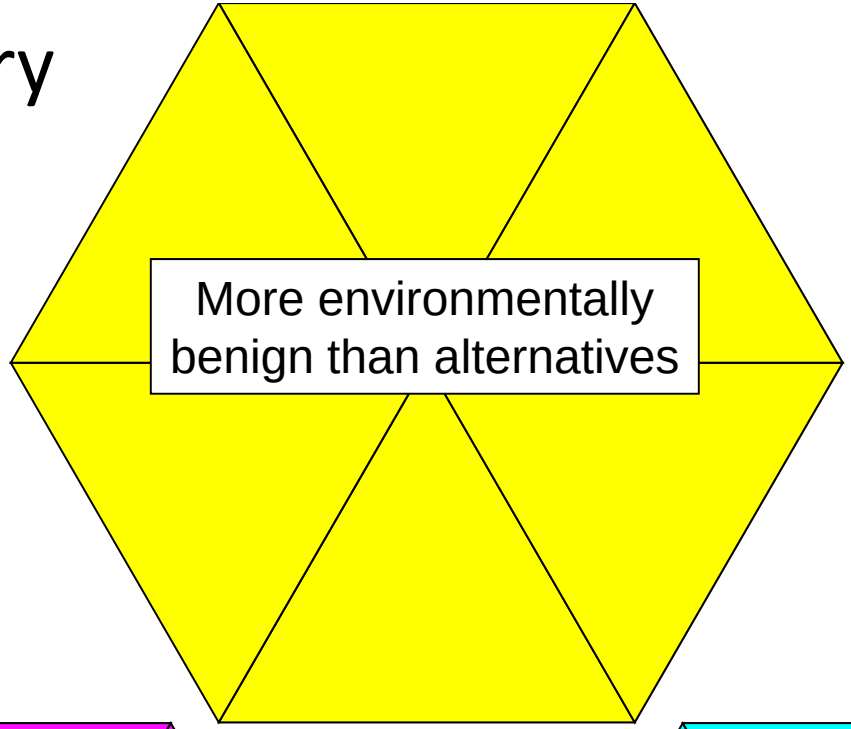
9. Catalysis. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

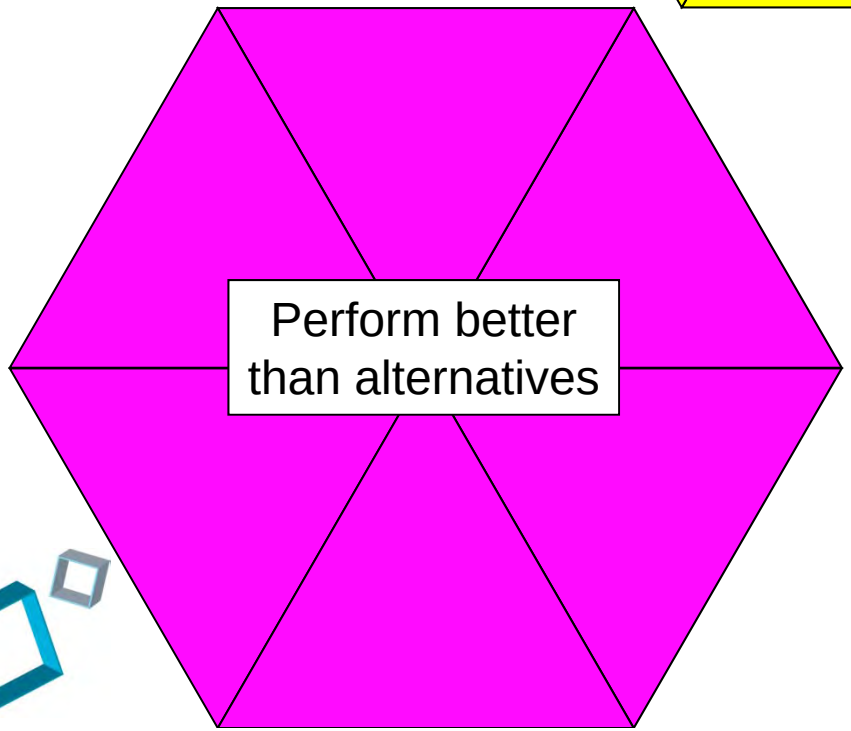
10. Design for Degradation. Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.

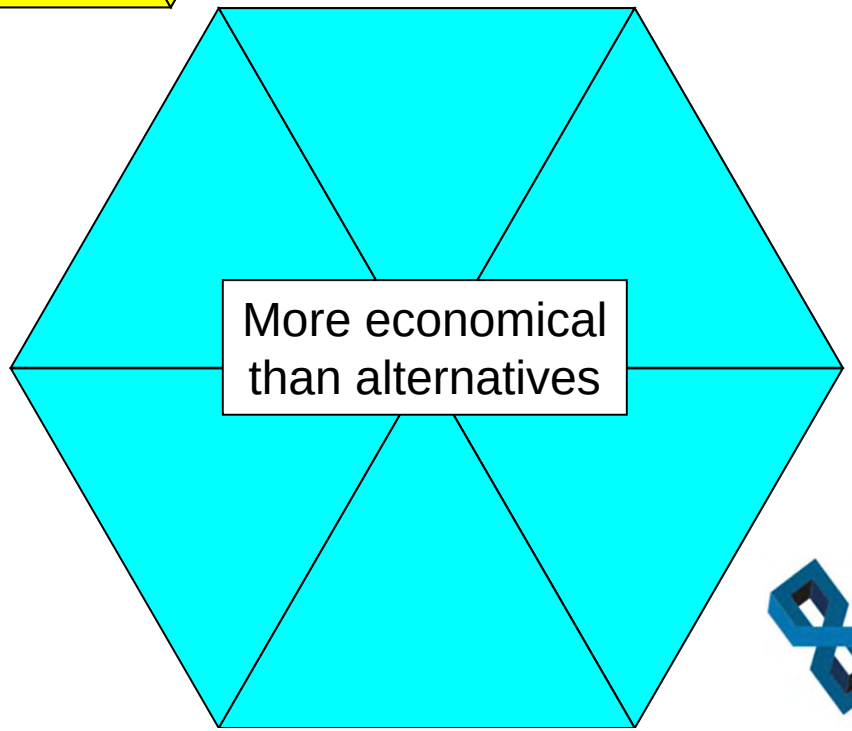
11. Real-time Analysis for Pollution Prevention. Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.

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.

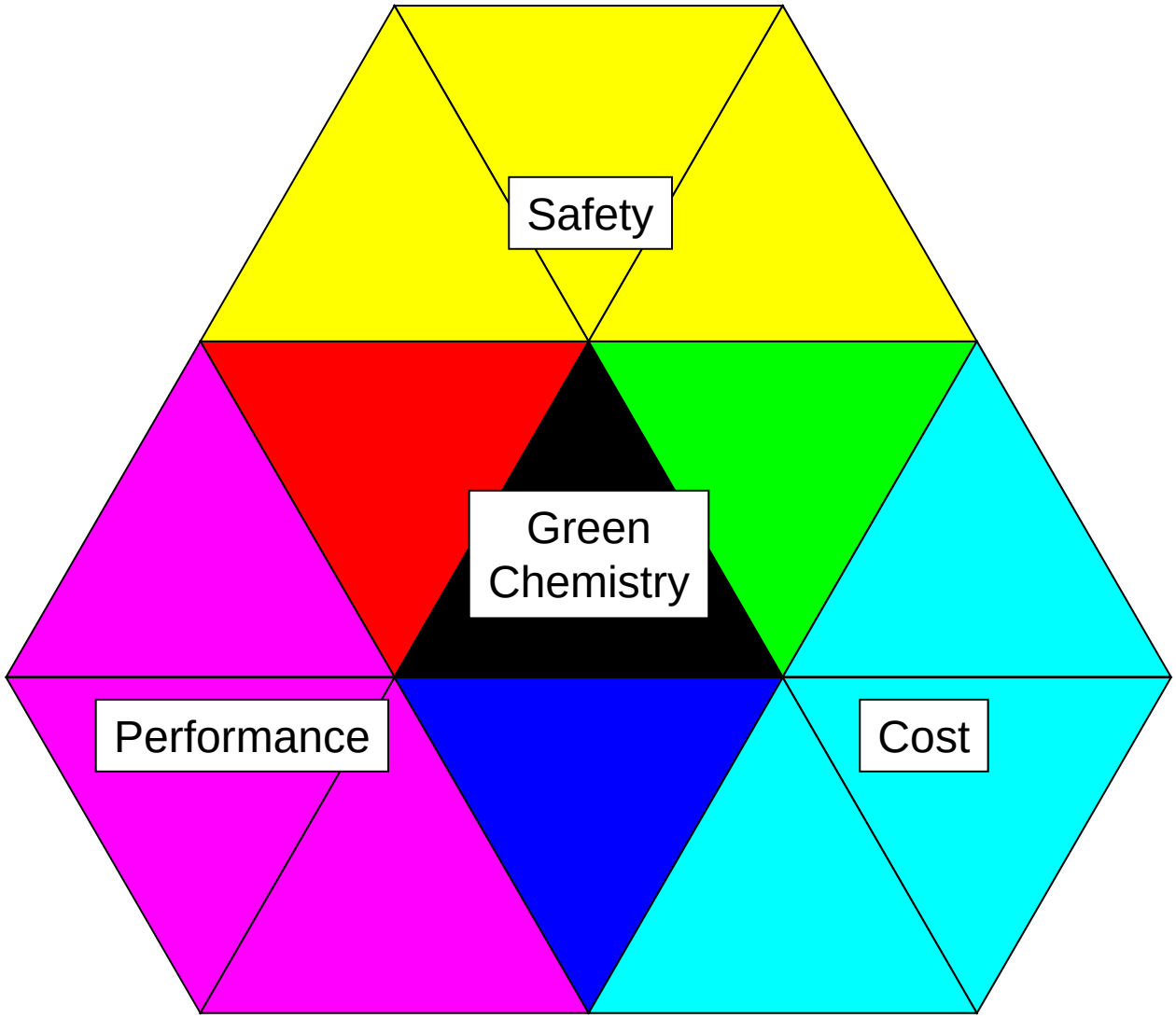
Green Chemistry







Green Chemistry

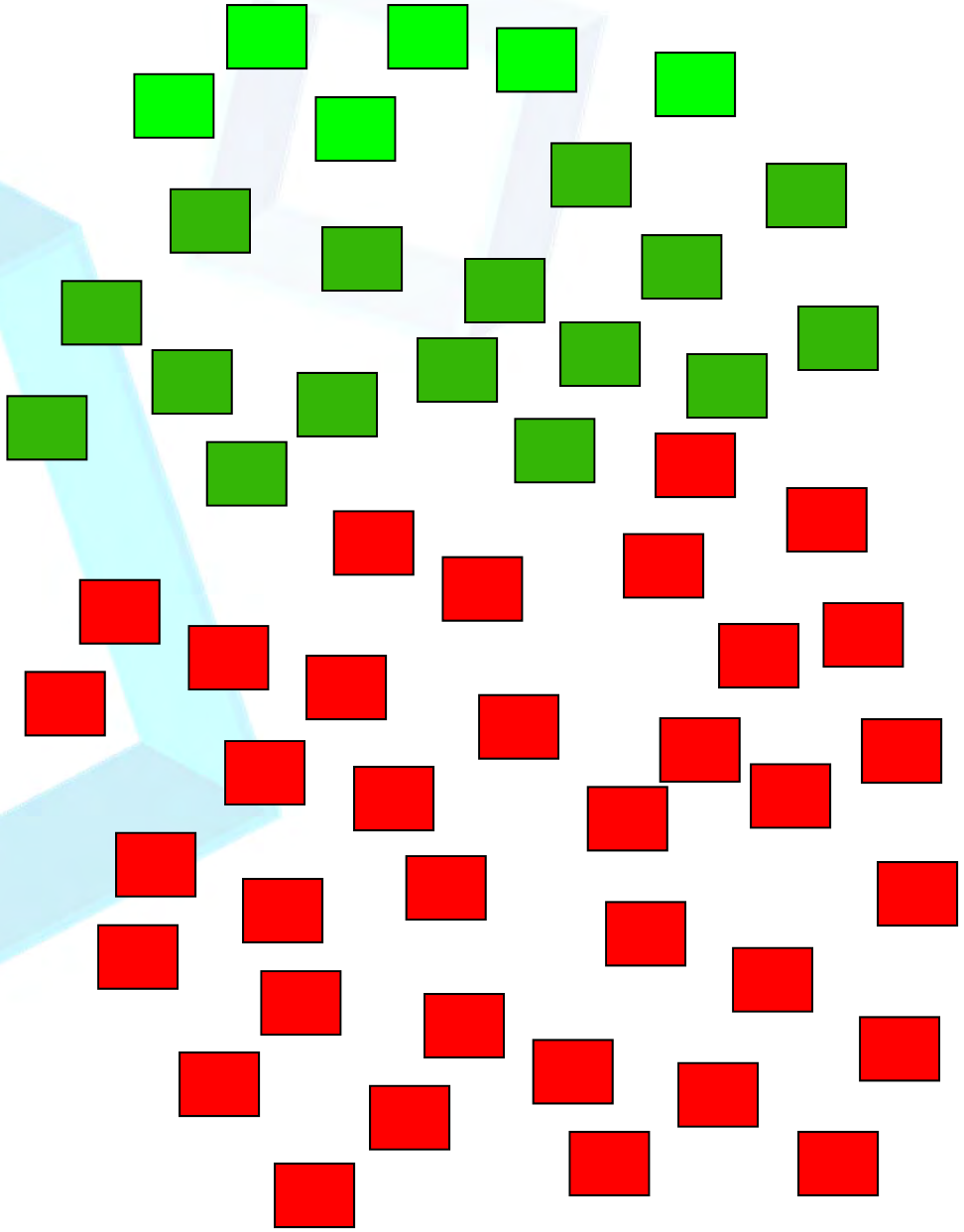


Of all the products and processes…

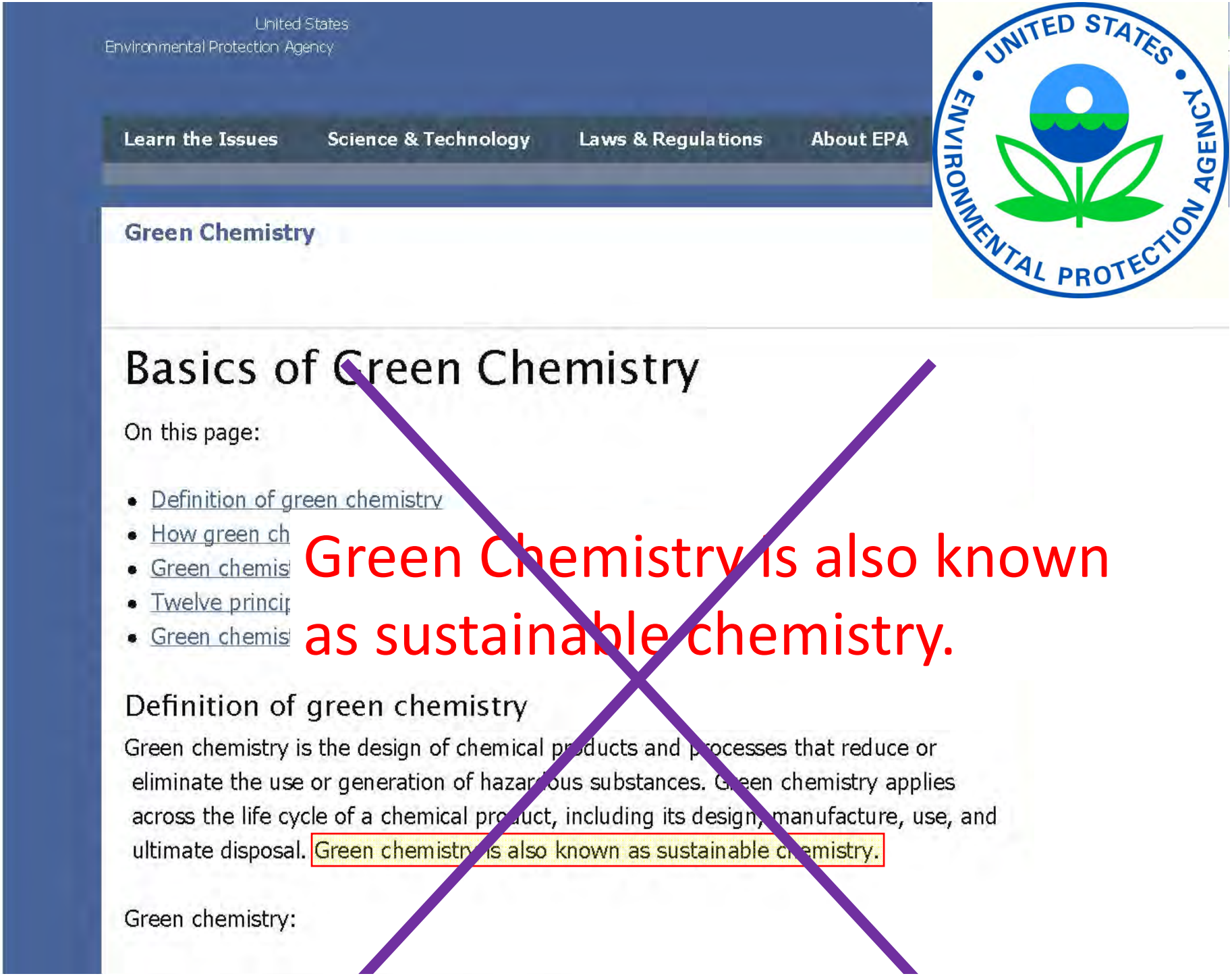
Maybe 10% are benign…

Maybe 25% have alternatives available…

65% Still have to be invented!



How does Green Chemistry fit into the big picture of Sustainability.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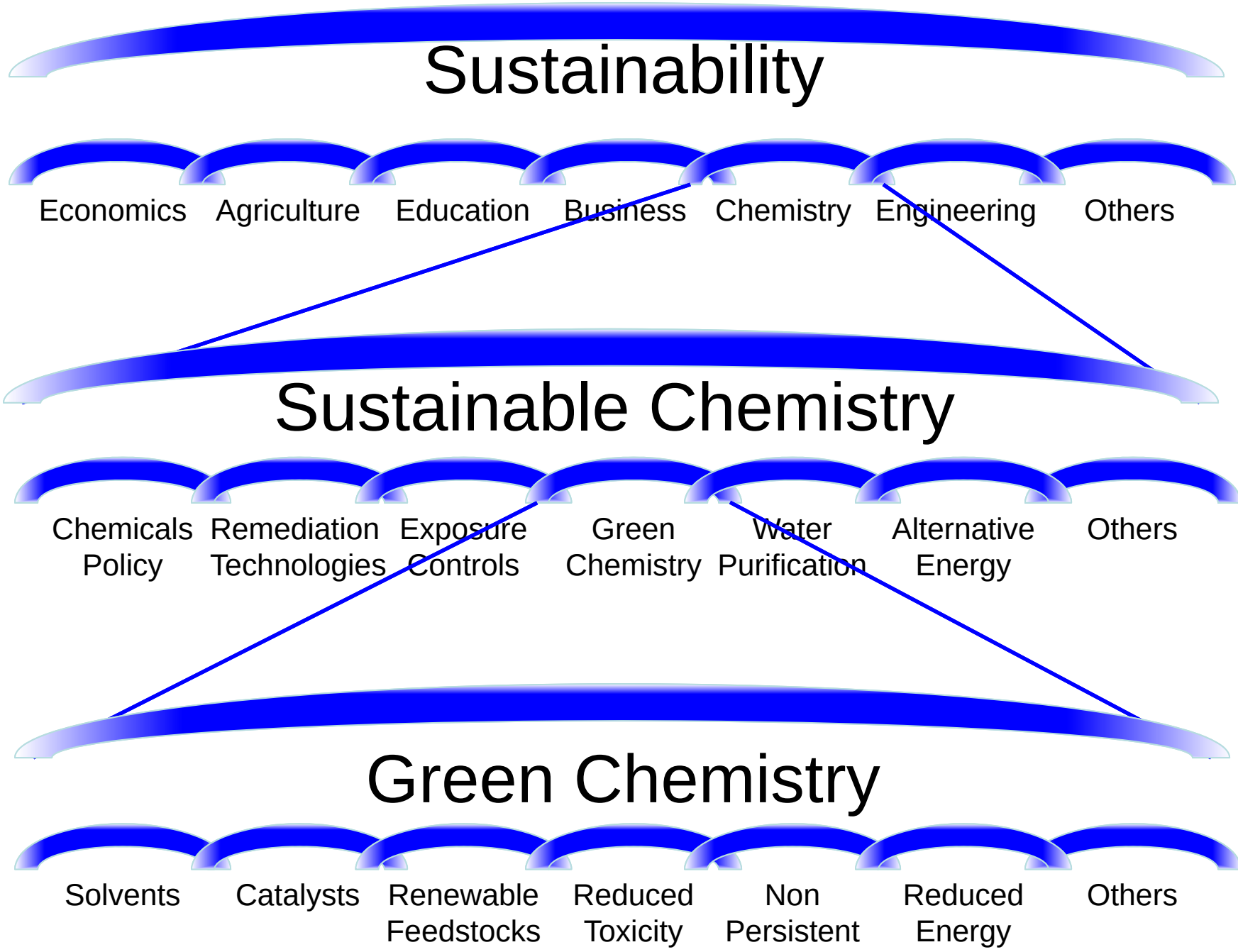
Science & Technology
Laws & Regulations
About EPA
Green Chemistry
Basics of Green Chemistry
On this page:
Definition of green chemistry
How green ch
Green chemis
Twelve princi
Green chemis
Green Chemistry is also known as sustainable chemistry.
Definition of green chemistry
Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal. Green chemistry is also known as sustainable chemistry.
Green chemistry:


Sustainability
Economics
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Green Chemistry
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Reduced Energy
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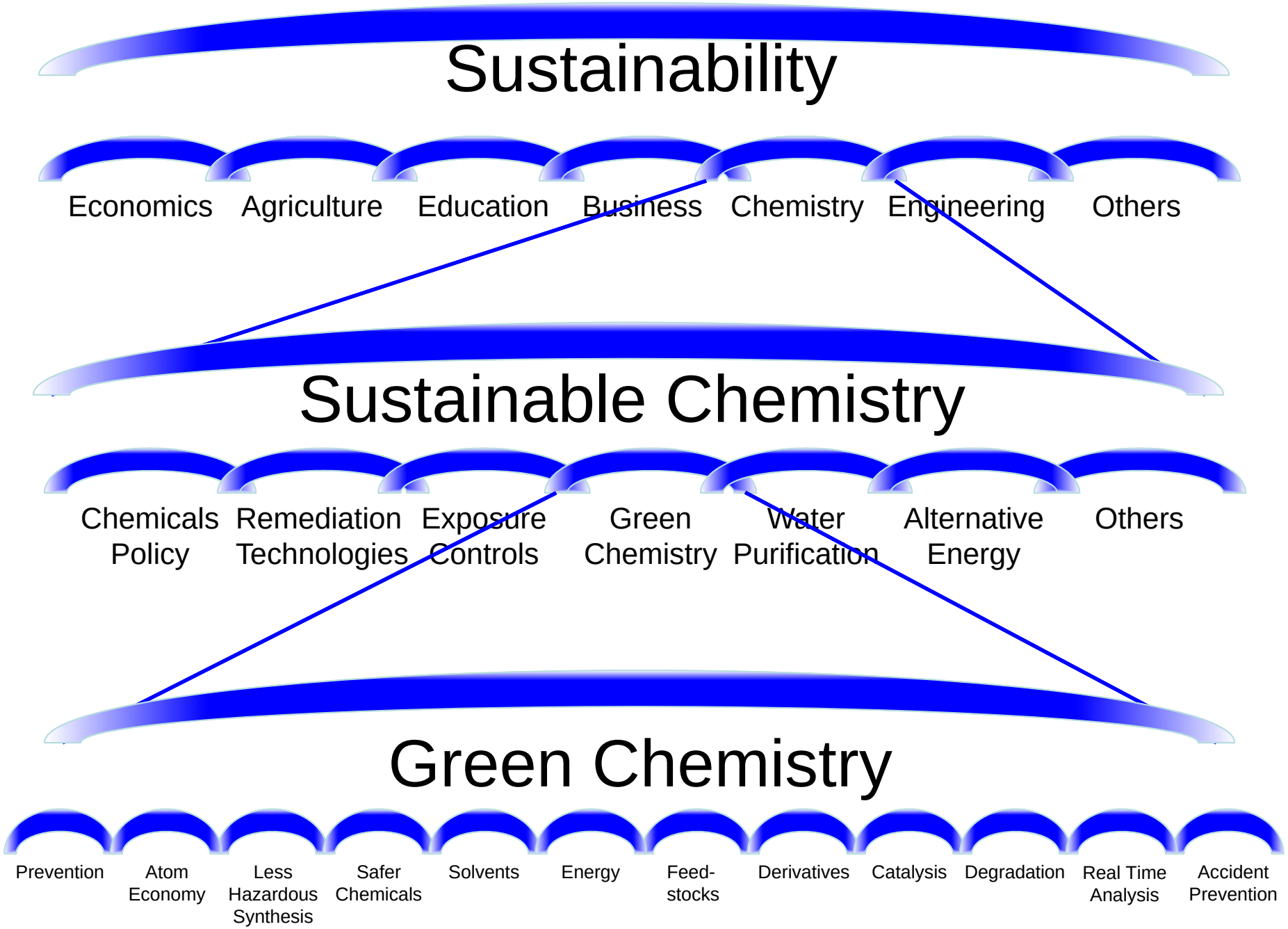
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Less Hazardous Synthesis
Safer Chemicals
Solvents
Energy
Feed-stocks
Derivatives
Catalysis
Degradation
Real Time Analysis
Accident Prevention

Today's Talk:

- Green Chemistry
- Product Design
- Zero and Big Numbers
- How it fits together
- Examples from WBI

Product Design

Identify and prioritize key attributes

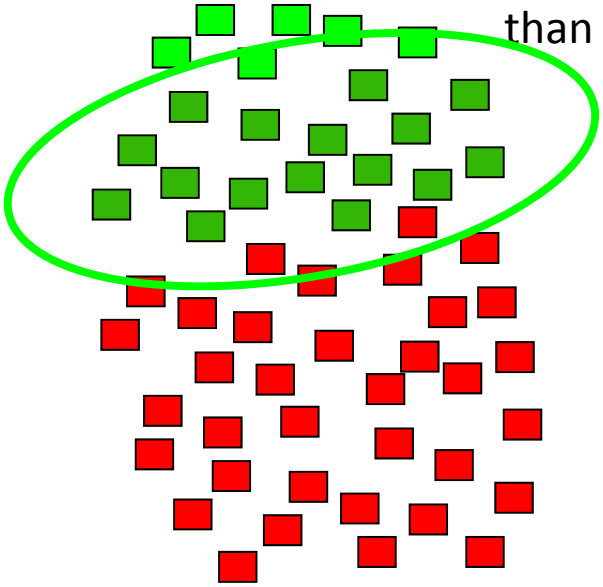
Design/plan metrics and tools to evaluate

Identify possible existing materials

Measure/Quantify performance of materials

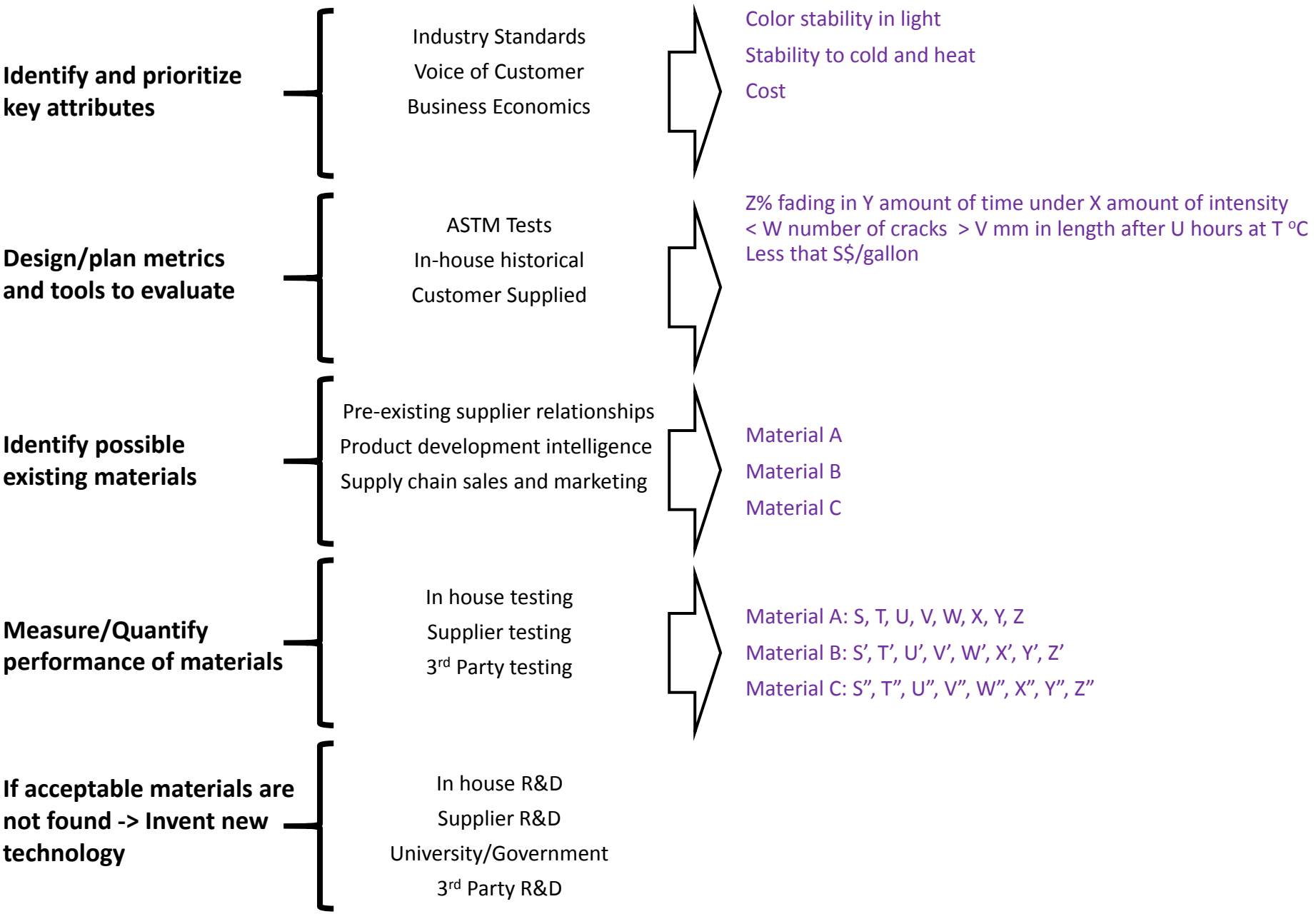
If acceptable materials are not found -> Invent new technology

If acceptable materials are found –> Make Product

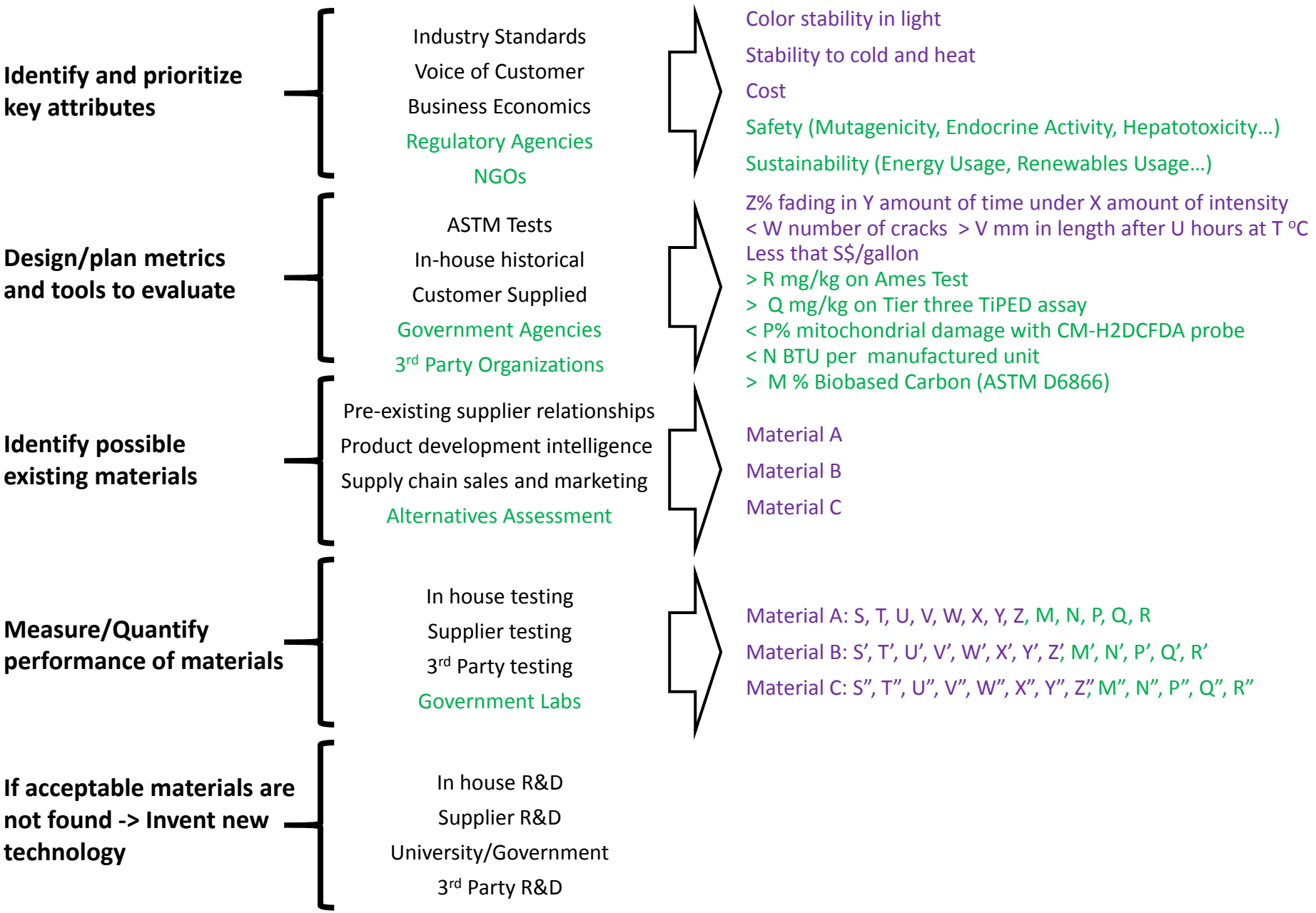


This will happen less than 25% of the time.

Performance and Cost



Performance, Cost, Safety and Sustainability



A deliverable attribute must be:

Quantifiable

Color doesn't fade.

Achievable

Color NEVER fades (IS NOT achievable)
Color only fades a little over a certain period of time (IS achievable)

Measurable

Optical density decreases by less than 10% after
48 hours with 20000 lumens solar simulator.

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Lets talk about nothing:

There are two issues with the use of “free” and “zero”:

(1) What does “chemical free” mean?

“BPA Free”:

(2) Can we ever have an “anything” free product?

● Handling receipts with care

Surprise: The thermal paper receipts from many ATMs and cash registers are coated with high levels of BPA, which can be absorbed through the skin or transferred from fingers to food, reveals research by John C. Warner, Ph.D., author of *Green Chemistry: Theory and Practice.*

BPA in cash register receipts….

No BPA added in the coating…

Unavoidable trace amounts of BPA in the paper!!!!

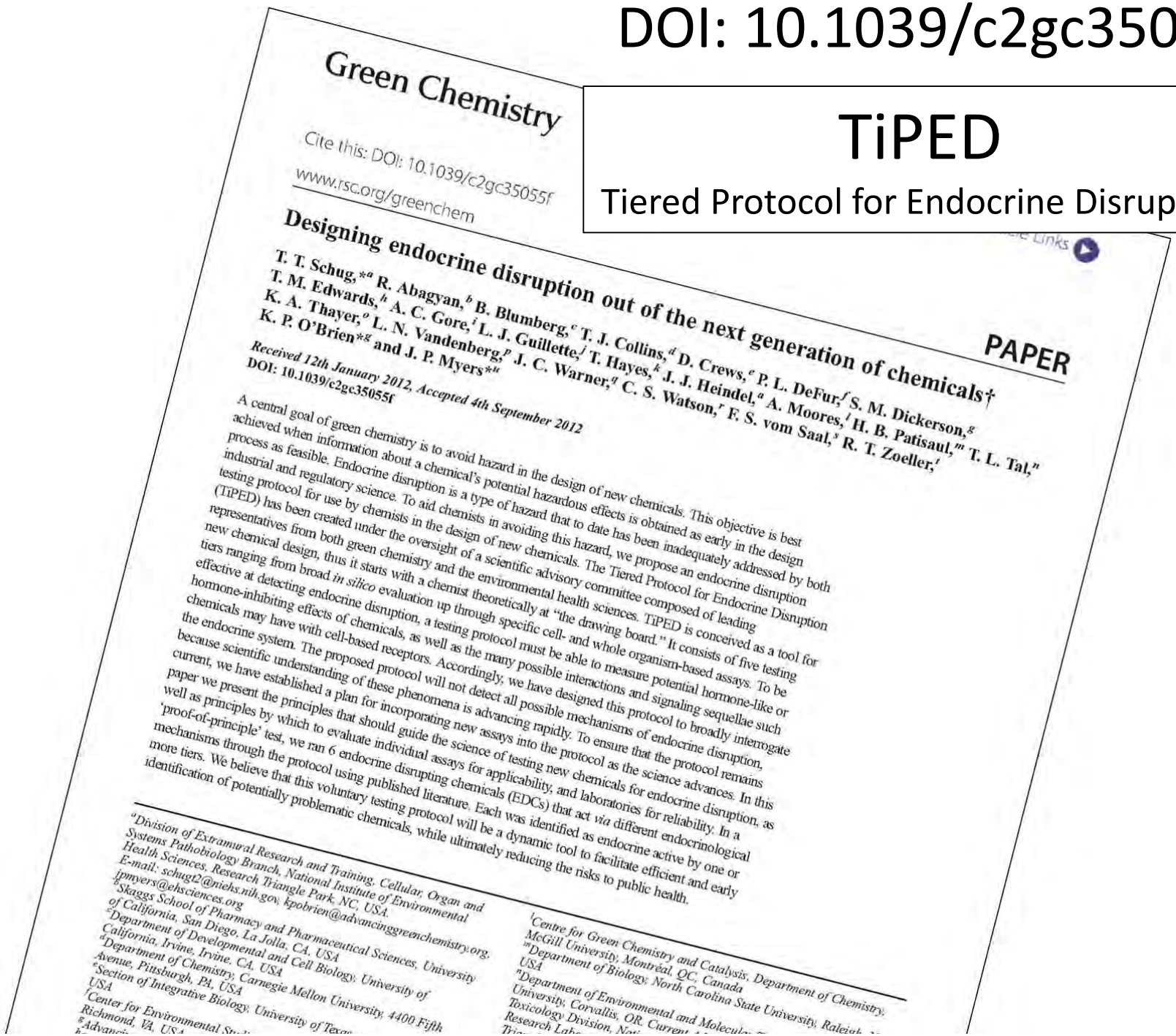
So what does “BPA-Free” mean?

Is it achievable?

DOI: 10.1039/c2gc35055f

TiPED

Tiered Protocol for Endocrine Disruption



Green Chemistry

Cite this: DOI: 10.1039/c2gc35055f

www.rsc.org/greenchem

PAPER

Designing endocrine disruption out of the next generation of chemicals†

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A central goal of green chemistry is to avoid hazard in the design of new chemicals. This objective is best achieved when information about a chemical's potential hazardous effects is obtained as early in the design process as feasible. Endocrine disruption is a type of hazard that to date has been inadequately addressed by both industrial and regulatory science. To aid chemists in avoiding this hazard, we propose an endocrine disruption testing protocol for use by chemists in the design of new chemicals. The Tiered Protocol for Endocrine Disruption (TiPED) has been created under the oversight of a scientific advisory committee composed of leading representatives from both green chemistry and the environmental health sciences. TiPED is conceived as a tool for new chemical design, thus it starts with a chemist theoretically at "the drawing board." It consists of five testing tiers ranging from broad *in silico* evaluation up through specific cell- and whole organism-based assays. To be effective at detecting endocrine disruption, a testing protocol must be able to measure potential hormone-like or hormone-inhibiting effects of chemicals, as well as the many possible interactions and signaling sequellae such chemicals may have with cell-based receptors. Accordingly, we have designed this protocol to broadly interrogate the endocrine system. The proposed protocol will not detect all possible mechanisms of endocrine disruption, because scientific understanding of these phenomena is advancing rapidly. To ensure that the protocol remains current, we have established a plan for incorporating new assays into the protocol as the science advances. In this paper we present the principles that should guide the science of testing new chemicals for endocrine disruption, as well as principles by which to evaluate individual assays for applicability, and laboratories for reliability. In a 'proof-of-principle' test, we ran 6 endocrine disrupting chemicals (EDCs) that act *via* different endocrinological mechanisms through the protocol using published literature. Each was identified as endocrine active by one or more tiers. We believe that this voluntary testing protocol will be a dynamic tool to facilitate efficient and early identification of potentially problematic chemicals, while ultimately reducing the risks to public health.

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“Nothing” and Big Numbers:

55 Gal Drum water

6.97×10^{27} Molecules of water

6 9 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Teaspoon of sugar

7.93×10^{21} Molecules of sugar 1.14 ppm

7 9 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Grain of sugar

5.22×10^{17} Molecules of sugar 50.6 ppt

3 5 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Nanogram of sugar

1.76×10^{12} Molecules of sugar

176 Billion molecules of sugar

1 7 6 0 0 0 0 0 0 0 0 0

Amedeo Avogadro

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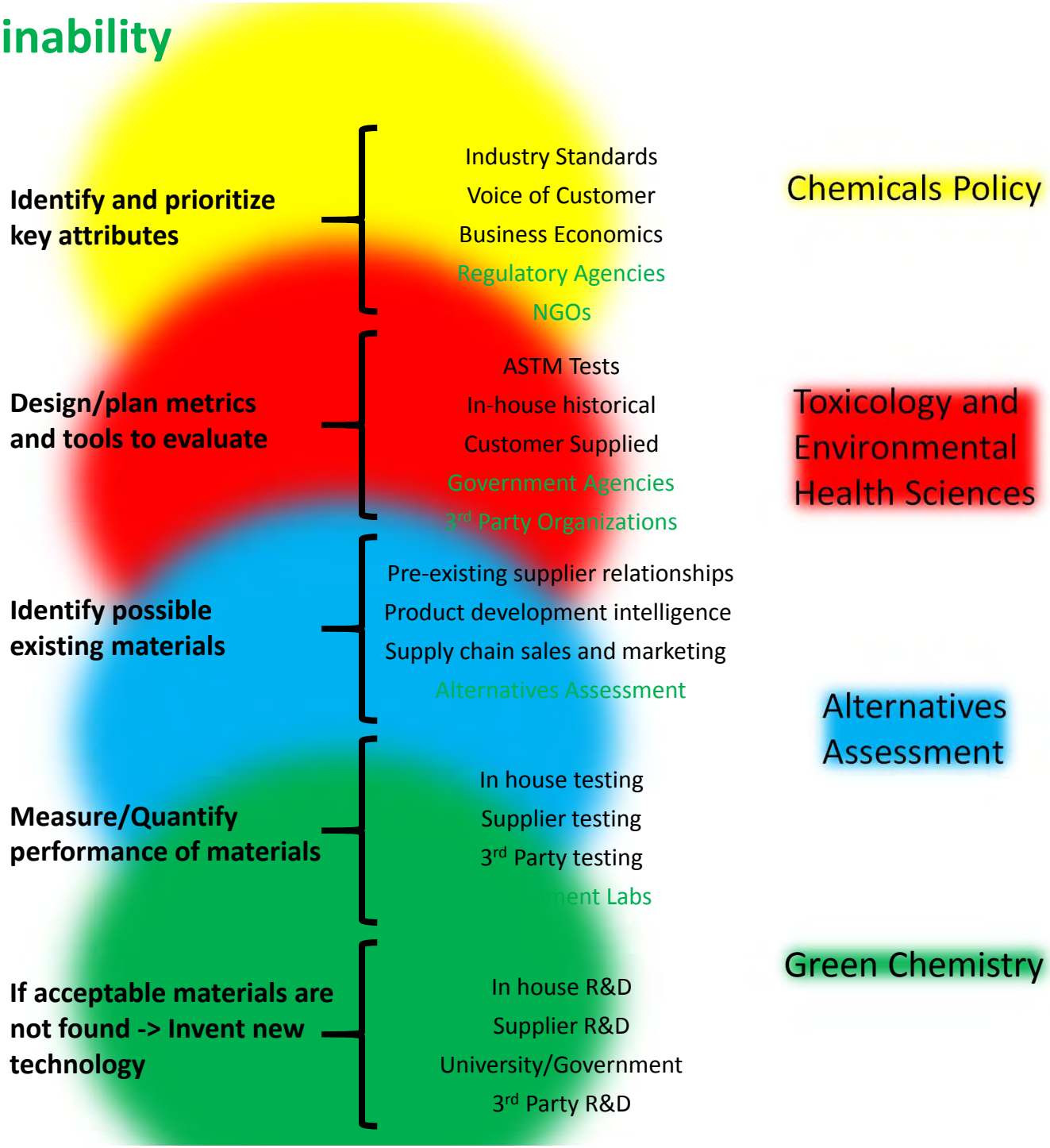
The ability to invent & design solutions to a problem is directly proportional to the quality of the description of success.

Quantifiable
Achievable
Measurable

Safety and Sustainability



We can’t sit on our hands waiting for all the criteria to be sorted out.

While zero may not be achievable from a regulatory perspective…

From an innovation and design perspective, it will always point us in the right direction.

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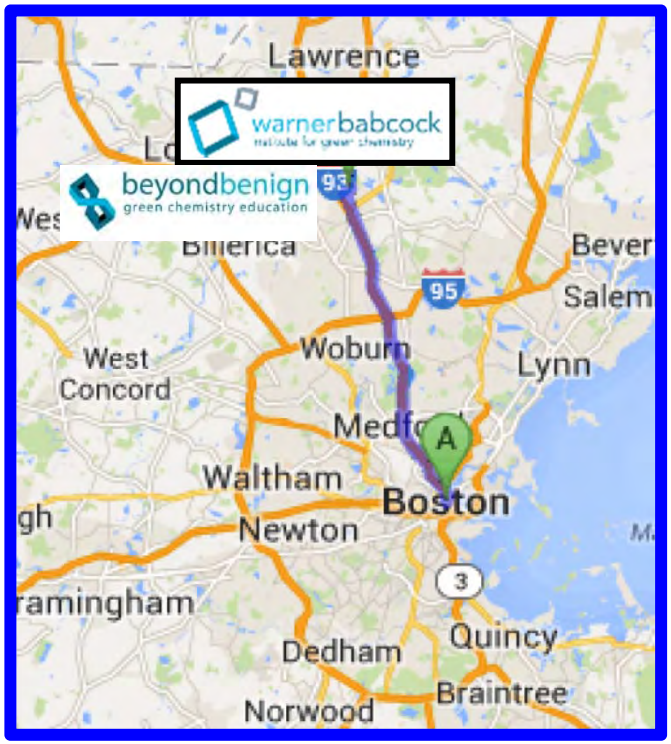
John Warner **Amy Cannon** **Jim Babcock** **Joe Pont, CEO**



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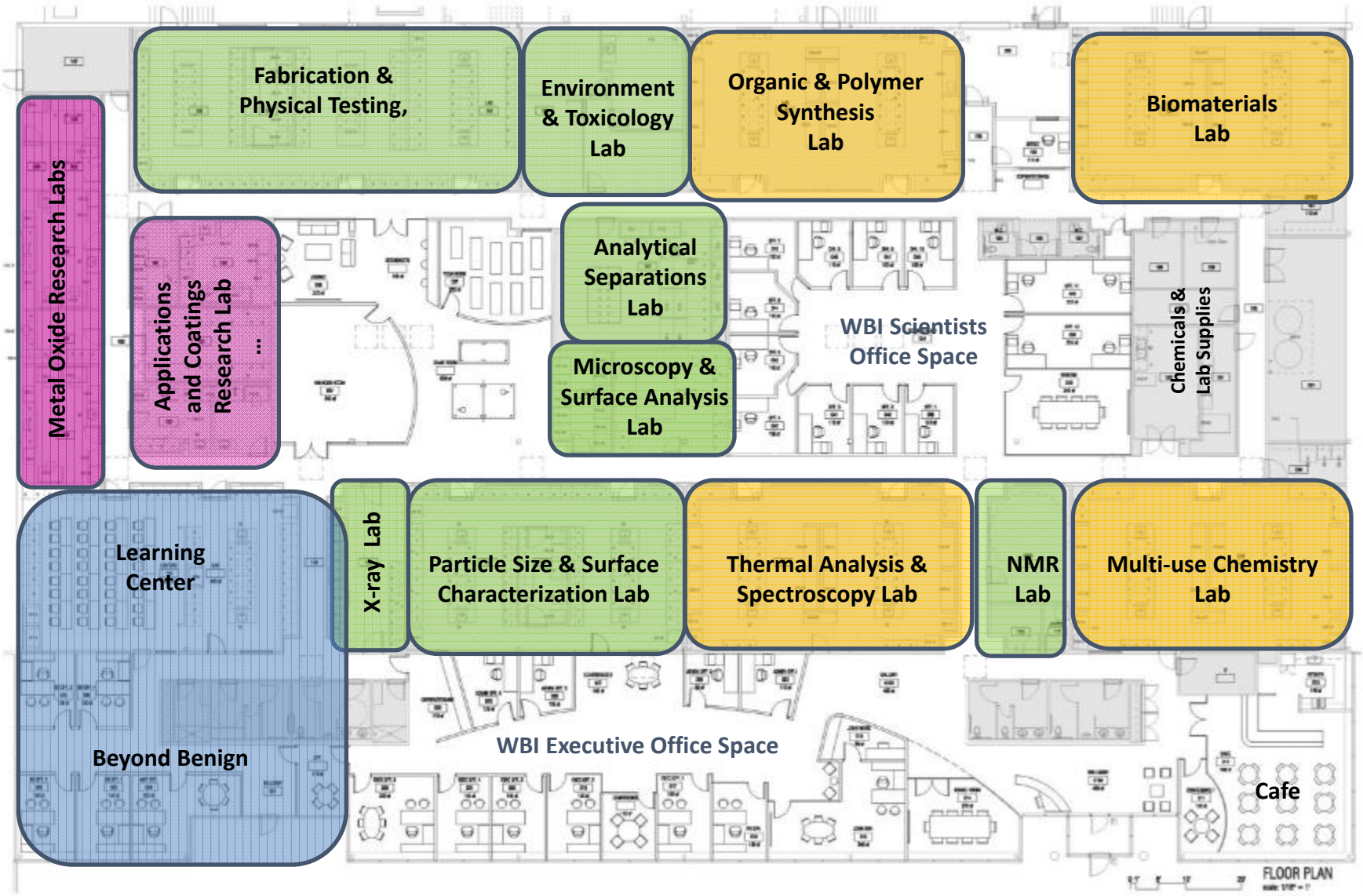
Wilmington, MA 01887


Fabrication & Physical Testing,
Environment & Toxicology Lab
Organic & Polymer Synthesis Lab
Biomaterials Lab
Metal Oxide Research Labs
Applications and Coatings Research Lab
...
Analytical Separations Lab
Microscopy & Surface Analysis Lab
WBI Scientists Office Space
Chemicals & Lab Supplies
Learning Center
Beyond Benign
X-ray Lab
Particle Size & Surface Characterization Lab
Thermal Analysis & Spectroscopy Lab
NMR Lab
Multi-use Chemistry Lab
WBI Executive Office Space
Cafe
FLOOR PLAN

Science

Business

Explore

Observe and define structure and dynamics.

Basic Research

Understand

Identify and characterize impact of changes of structure on dynamics and dynamics on structure.

Parameterize

Design alterations in structure and/or dynamics to purposefully control response.

Technology Greenhouse

Market Analysis

Explore

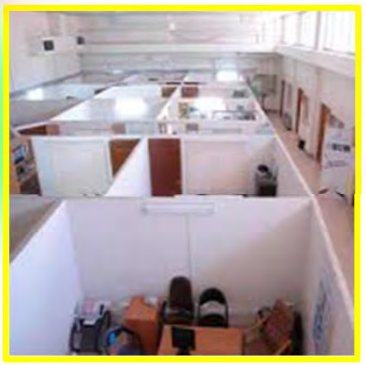
Observe and define a product and market.

Understand

Identify and characterize market history and likely future trends

Parameterize

Design potential products and assess potential markets and parameters for success.



Technology Incubator

Create

Create a potentially useful prototype.

Develop

Develop a potentially successful product.

Commercialize

Commercialize a successful product.

Business Sectors at WBI

Pharmaceuticals, Agriculture and Biotechnology

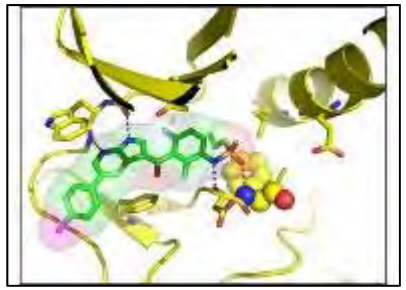
Chemical Sciences, Development and Manufacturing

Textiles, Materials and Coatings

Energy, Natural Resources and Environment

Cosmetics, Personal Care and Consumer

Business Sectors at WBI



Pharmaceuticals, Agriculture and Biotechnology

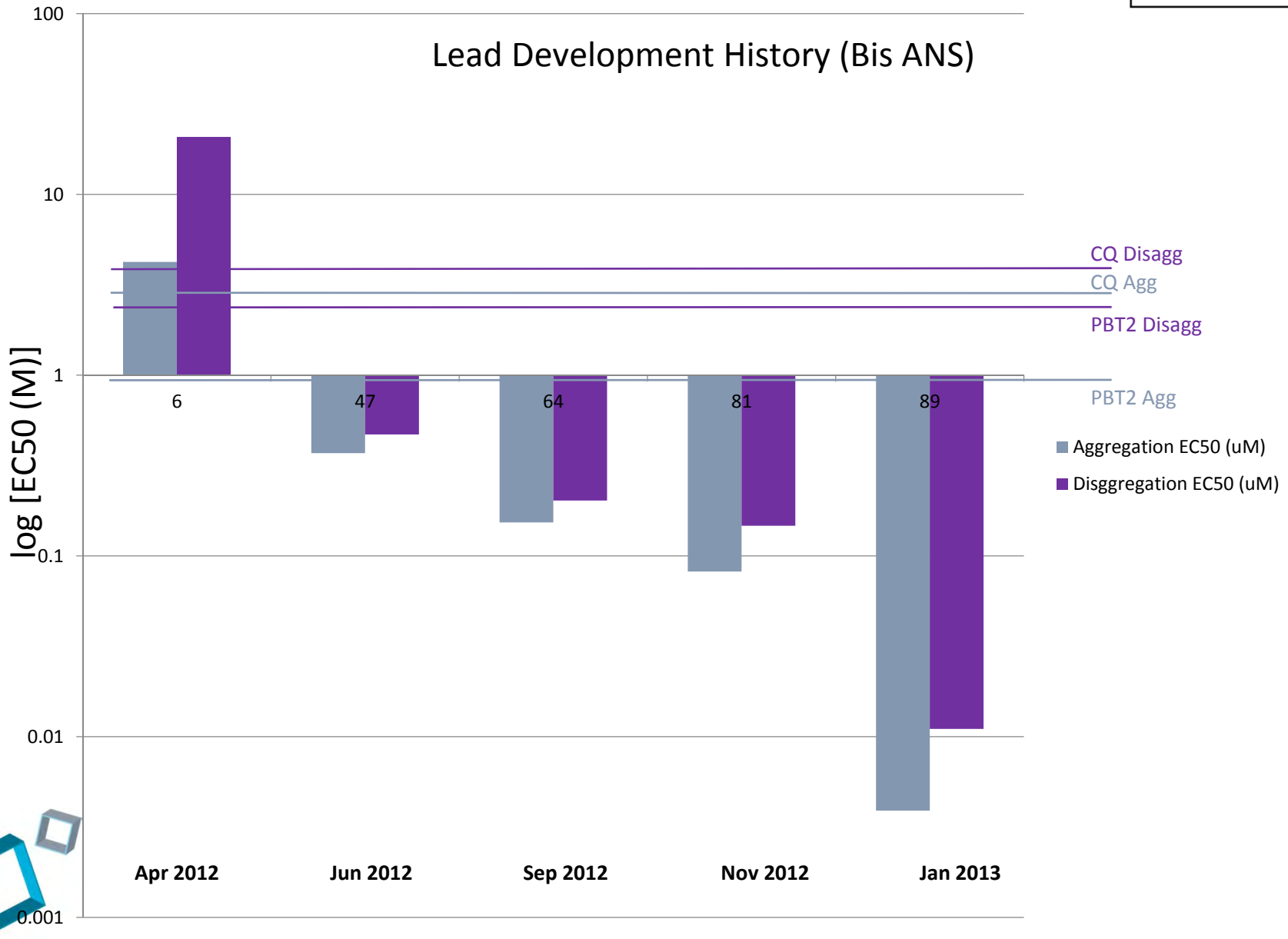
Chemical Sciences, Development and Manufacturing

Textiles, Materials and Coatings

Energy, Natural Resources and Environment

Cosmetics, Personal Care and Consumer

Alzheimer's Disease Therapeutic



Parkinson's Disease Therapeutic

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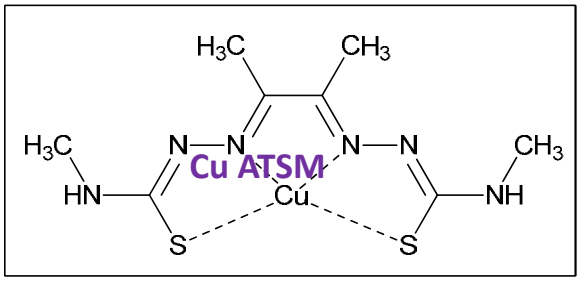

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PARKINSON'S FUNDED GRANT

Lead Optimization for a Parkinson's Disease Therapeutic

GRANT ABSTRACT

Objective/Rationale:
CuII(atsm) has the potential to delay disease progression in Parkinson's disease, based on extensive pre-clinical model data. CuII(atsm) has been shown to significantly improve motor function in standard models of Parkinson's disease. The observed motor improvement correlates with preservation of dopaminergic neurons in the brain and biomarkers of neuronal health and function.

Project Description:
CuII(atsm) is sparingly soluble and requires formulation for oral administration prior to entering human clinical development. Procypra will pursue two parallel approaches to develop a proprietary oral formulation: (1) Procypra will work with the Warner Babcock Institute for Green Chemistry to develop a proprietary formulation of CuII(atsm) incorporating GRAS (Generally Regarded As Safe) excipients; and (2) Procypra will evaluate the solubility of proprietary CuII(atsm) analogues. The utility of these formulations will be evaluated using standard solubility and bioavailability assays and efficacy will be compared to the parent formulation in the MPTP toxic lesion pre-clinical model of Parkinson's disease.

Relevance to Diagnosis/Treatment of Parkinson's Disease:
CuII(atsm) has the potential to delay disease progression in Parkinson's disease. Successful clinical development of an optimized formulation of CuII(atsm) would provide Parkinson's disease patients, on diagnosis, the opportunity to delay the progression of their disease and maintain their quality of life for a much extended period of time. In

Related news

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University Activities Medicine and Health Science

University of Melbourne enters agreement to develop therapy for Parkinson's disease

11 October 2013

Business Sectors at WBI

Pharmaceuticals, Agriculture and Biotechnology

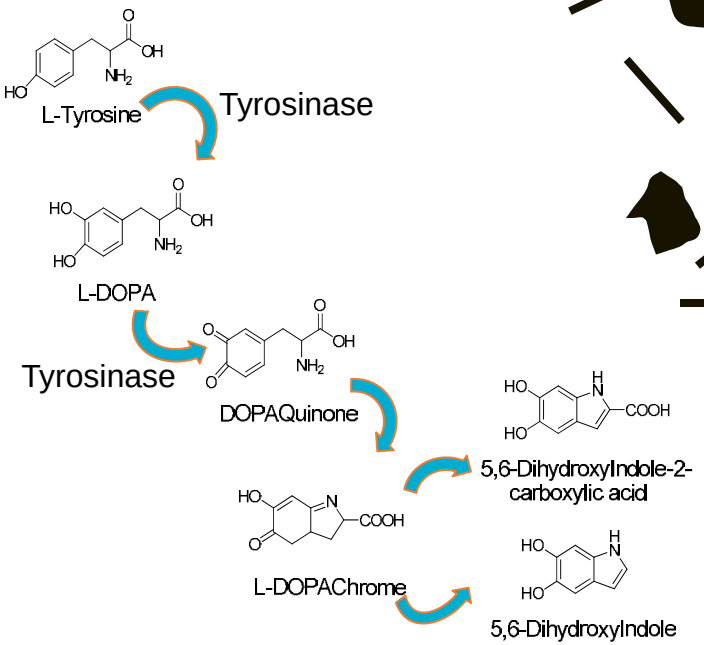
Chemical Sciences, Development and Manufacturing

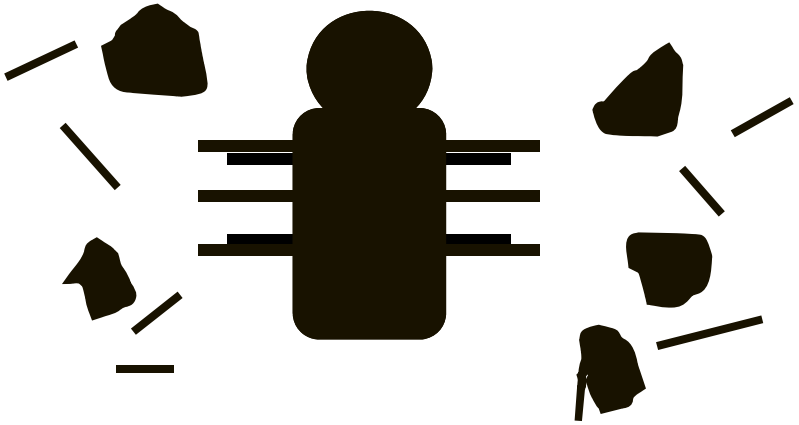
Textiles, Materials and Coatings

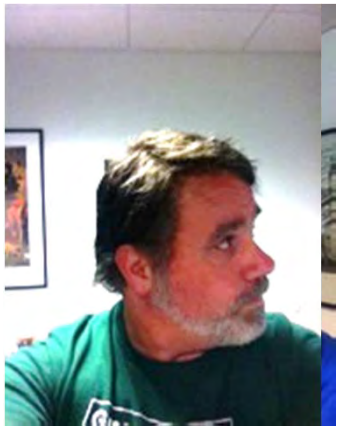
Energy, Natural Resources and Environment

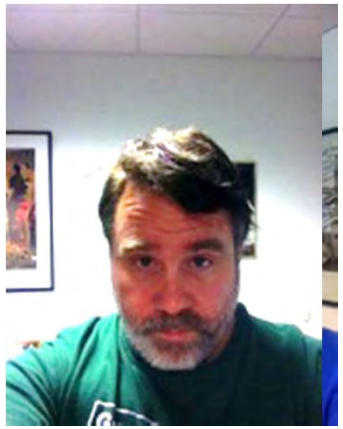
Cosmetics, Personal Care and Consumer

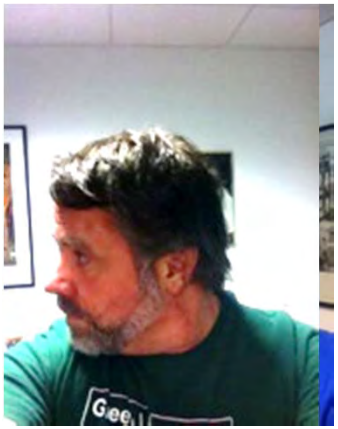
Non-Toxic Natural Hair Color Restoration

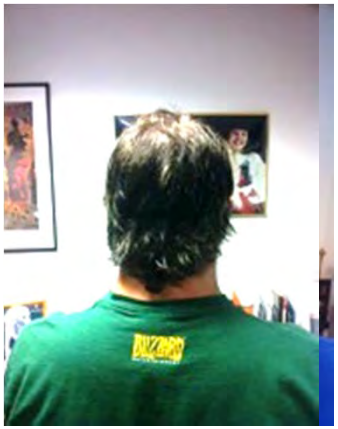












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(After)

Business Sectors at WBI

Pharmaceuticals, Agriculture and Biotechnology

Chemical Sciences, Development and Manufacturing

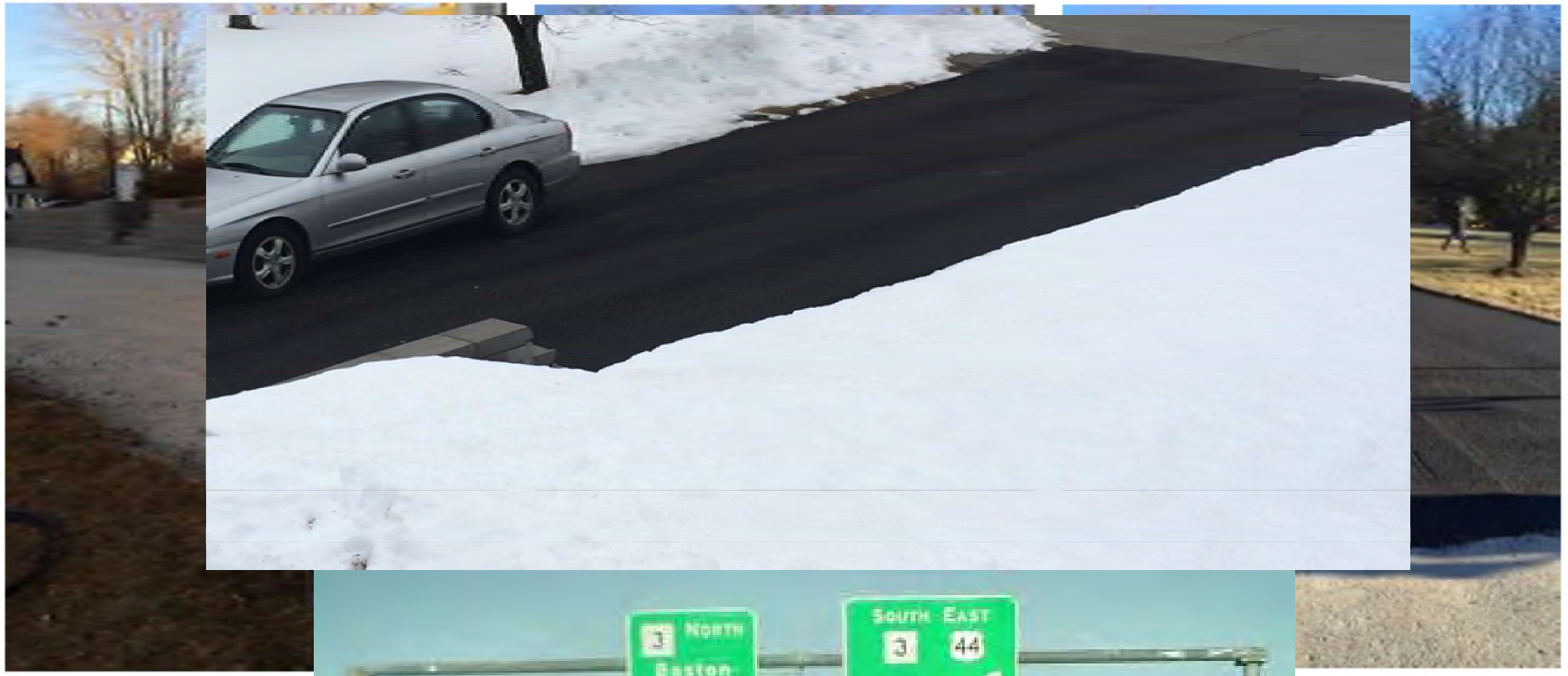
Textiles, Materials and Coatings

Energy, Natural Resources and Environment

Cosmetics, Personal Care and Consumer

Chemistry to increase use of recycled asphalt pavement and shingles

Paving with recycled asphalt and shingles



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.

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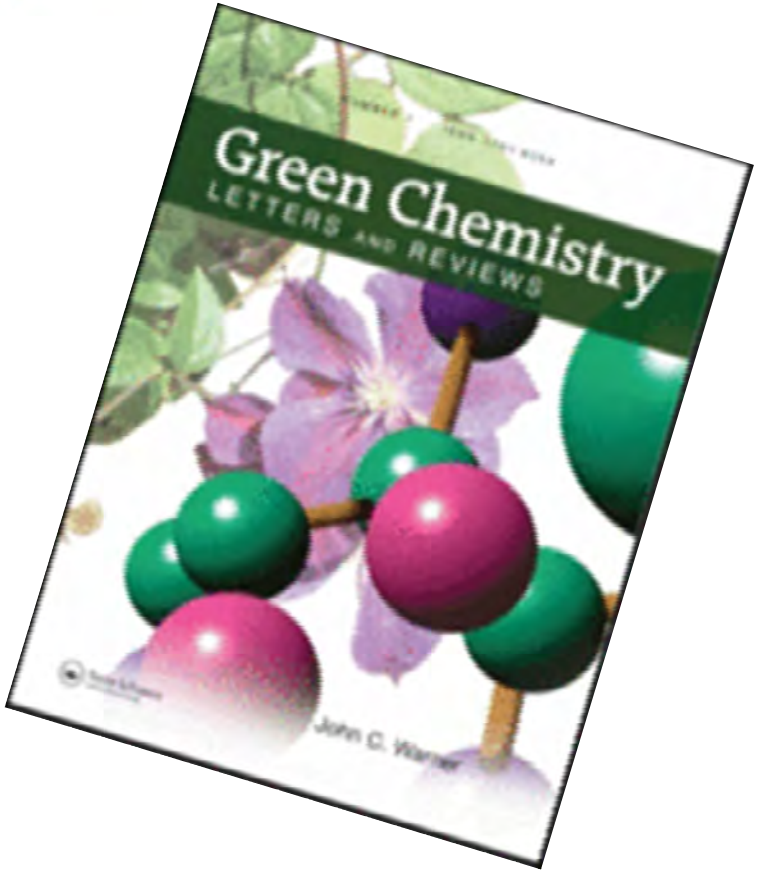

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GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

Upcoming Events

http://www.greenchemistryandcommerce.org/

The Coop Story: How a leading Danish Retailer is working to eliminate endocrine disrupting chemicals from its products, **Wednesday, April 30, 1pm est/10am pst**

And….

9th Annual
GREEN CHEMISTRY & COMMERCE COUNCIL
Innovators Roundtable
MAY 28–30 2014
St. Paul, Minnesota
Hosted by 3M

GREEN CHEMISTRY & COMMERCE COUNCIL

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THANK YOU!