

# Green Chemistry and Pollution Prevention

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National Pretreatment & P2 Workshop  
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Extension

# What is a hazardous chemical?

- ◆ Physio-chemical properties
- ◆ Public health
- ◆ Eco-toxicological

*PAHs*

*Endocrine Disruptors*

*Flame Retardants*

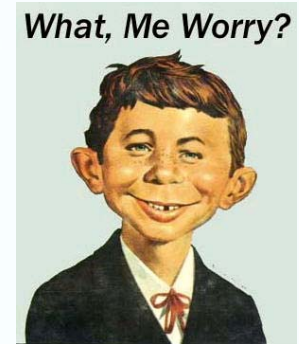
*Bisphenol A*

*Phthalates*

*Carcinogens*

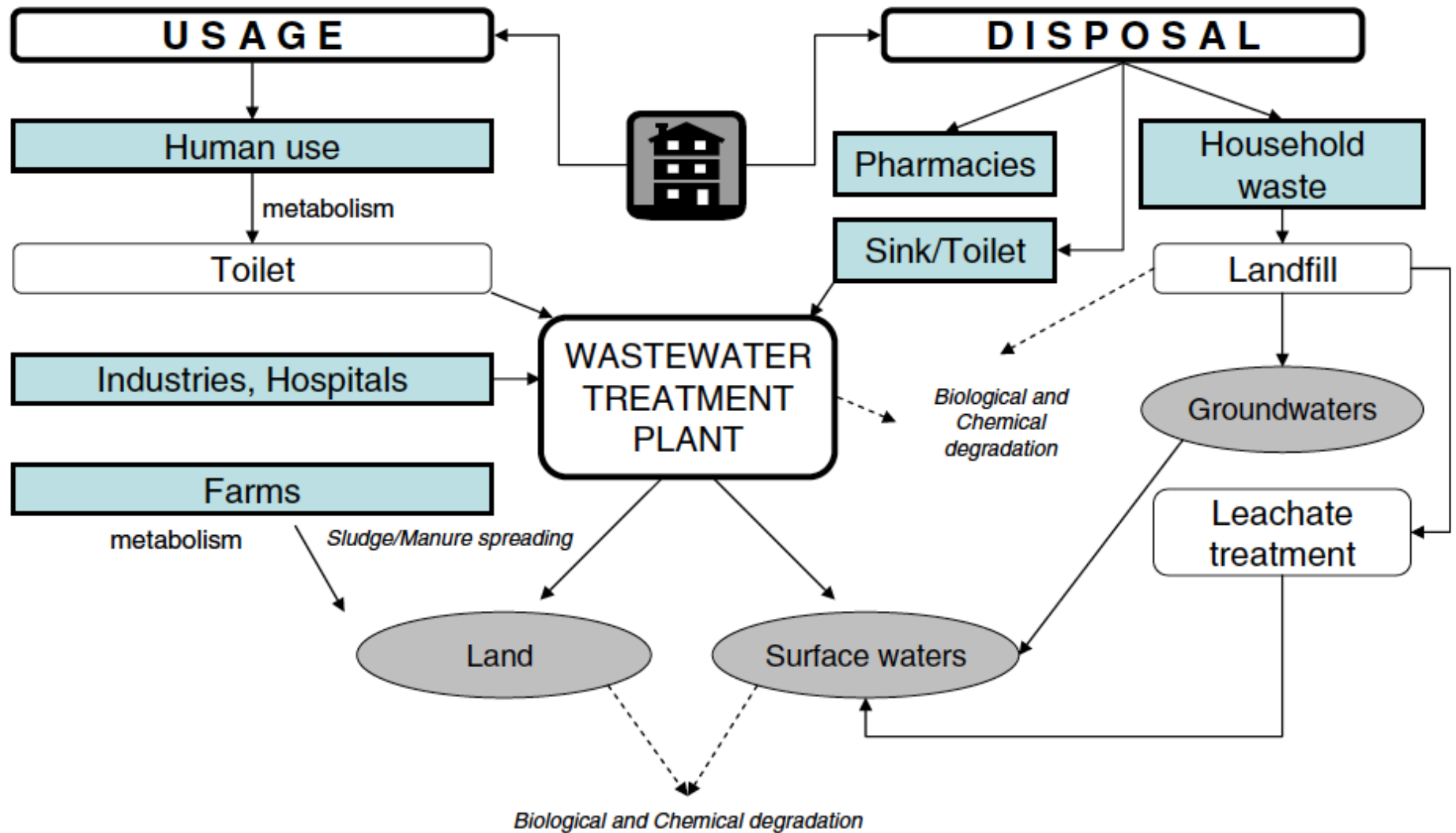
*Nonylphenol ethoxylates*

# Why the Concern?



- 84 k regulated chemicals (US)\*
  - General lack of complete health & environmental impact data
  - 62 k grandfathered in TSCA (1976)
    - Presumption innocence
    - Before 1976, no risk assessment or data on health effects requ'd
  - 2,500 Pre-manufacturing notices/year (EPA)

**\* 309 k worldwide**



**Eco-toxicological effects:**  
surface waters: uptake (aquatic species)  
land: uptake (plants), leaching, runoff

- “The removal of pharmaceuticals, personal care products, endocrine disruptors and illicit drugs during wastewater treatment and its impact on the quality of receiving waters”
- “Occurrence of estrogenic endocrine disrupting chemicals: Concern in sewage plant effluent”
- “Runoff of pharmaceuticals and **personal care products** following application of biosolids to an agricultural field”
- “Transfer of wastewater associated pharmaceuticals and **personal care products** to crop plants from biosolids treated soil”

Some transformed chemicals are potentially more mobile or persistent than their parent compounds.

Some PPCP metabolites that have been conjugated into less biologically active forms within the consumer's body can become de-conjugated into their active forms during wastewater treatment or in the environment due to microbial action

Overall, the effectiveness of PPCP removal can be highly variable within and between waste water facilities due to general operating conditions, technology used, microbial community composition, and methods of disinfection

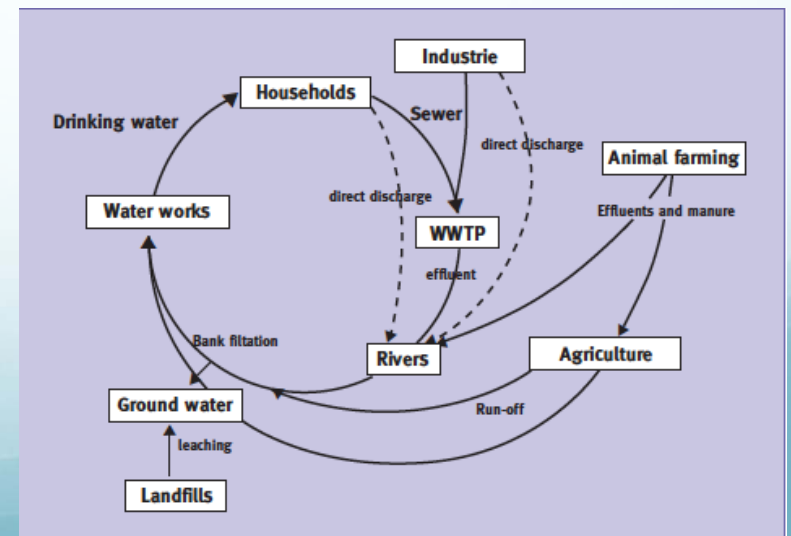
Relatively little can be inferred about removal and subsequent discharge of one chemical to another, as well as chemicals from one ww facility to another.

Source: Hedgespeth et al. 2012. Pharmaceuticals and personal care products (PPCPs) in treated wastewater discharges into Charleston Harbor, South Carolina. *Science of the Total Environment* 437:1–9

Today's conventional waste water treatment technology (mechanical and biological steps) dates back to the 1970s, and that it was designed to remove nitrogen and phosphorus.

Small polar organic molecules are poorly removed; many of the non-polar chemicals can however be removed with the sewage sludge.

Source: EU Wide Monitoring Survey on WWTP Effluents. 2012







# Microbeads

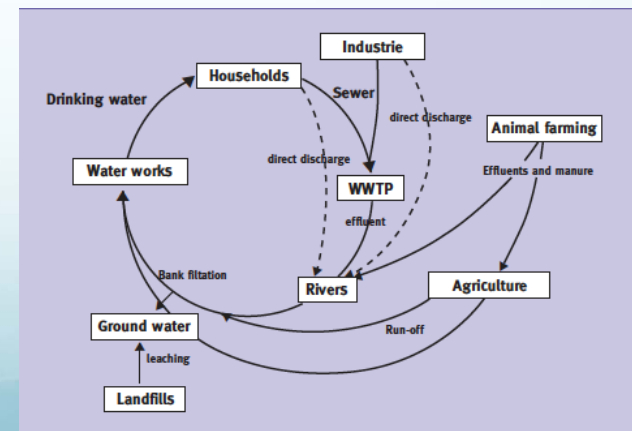
- Marine species are unable to distinguish between food and plastic microbeads
- Microbeads can act like sponges, absorbing toxic chemicals
- Water treatment plants not designed to filter out microbeads



# One Potential Solution

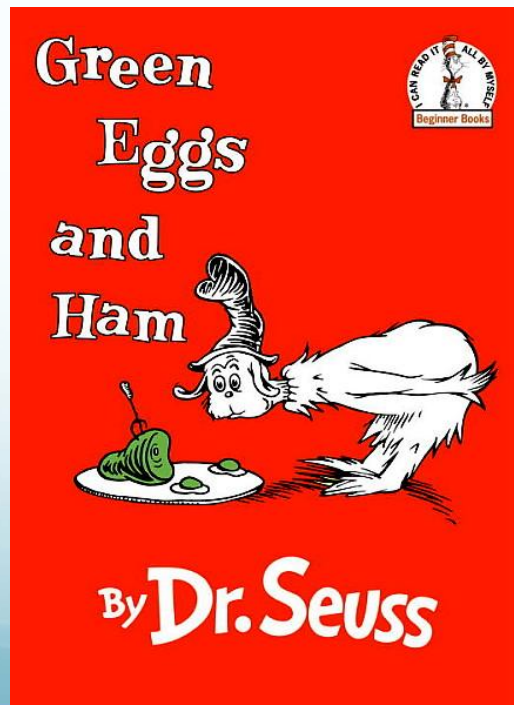
Source separation [of urine] may offer  
a more sustainable solution to the ww problem,  
for a wide variety of biologically active substances.  
These substances are excreted mostly via the urine.

Source: Municipal Waste Water Treatment Plant Effluents. 2007



# Green Chemistry

Does “Green Chemistry” mean  
“Green Eggs & Ham” ?





# Green Chemistry

The design of products and processes  
that reduce or eliminate  
the use or generation  
of **hazardous** substances

# Pollution Prevention (P2)

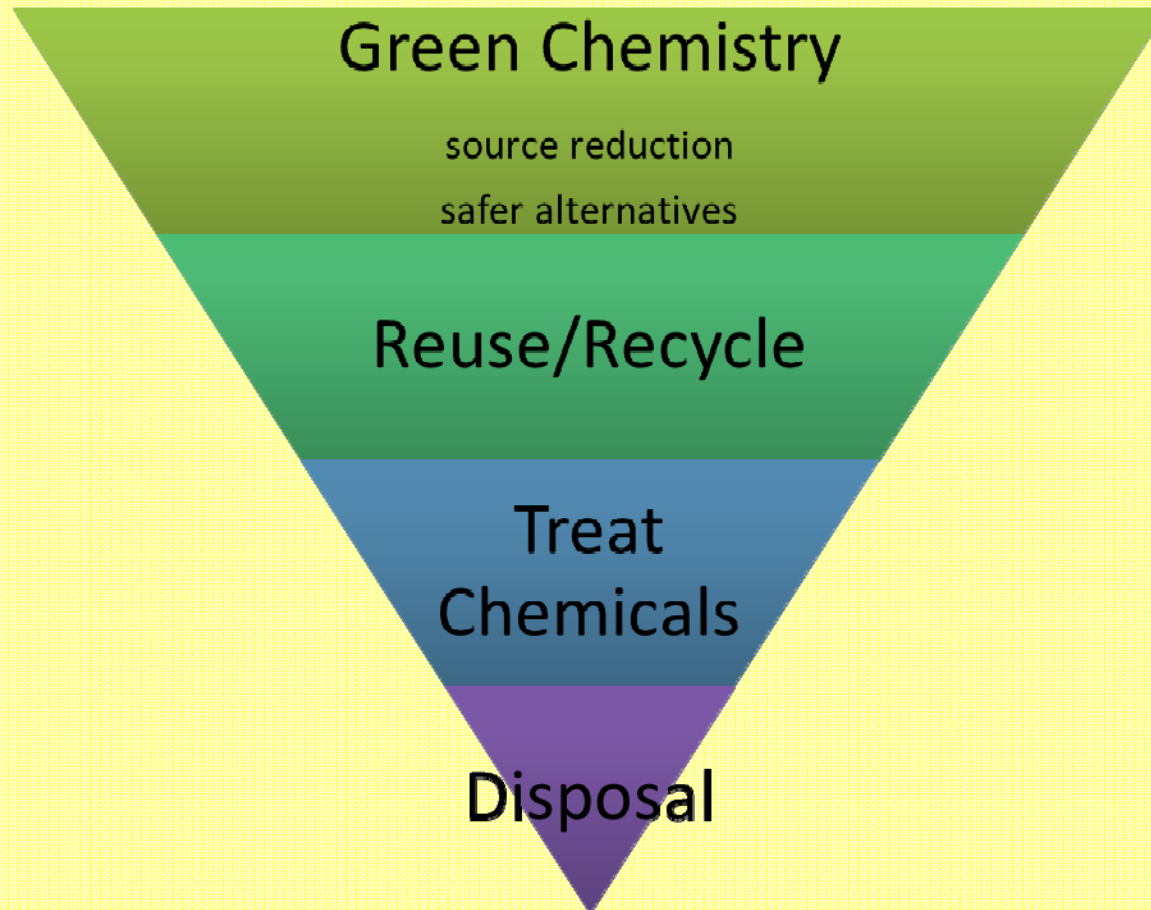
P2 = Source Reduction

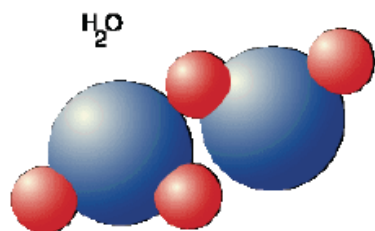
Reduce the generation of pollutants  
through more efficient use  
of raw materials and processes\*

\* Pollution Prevention Act of 1990

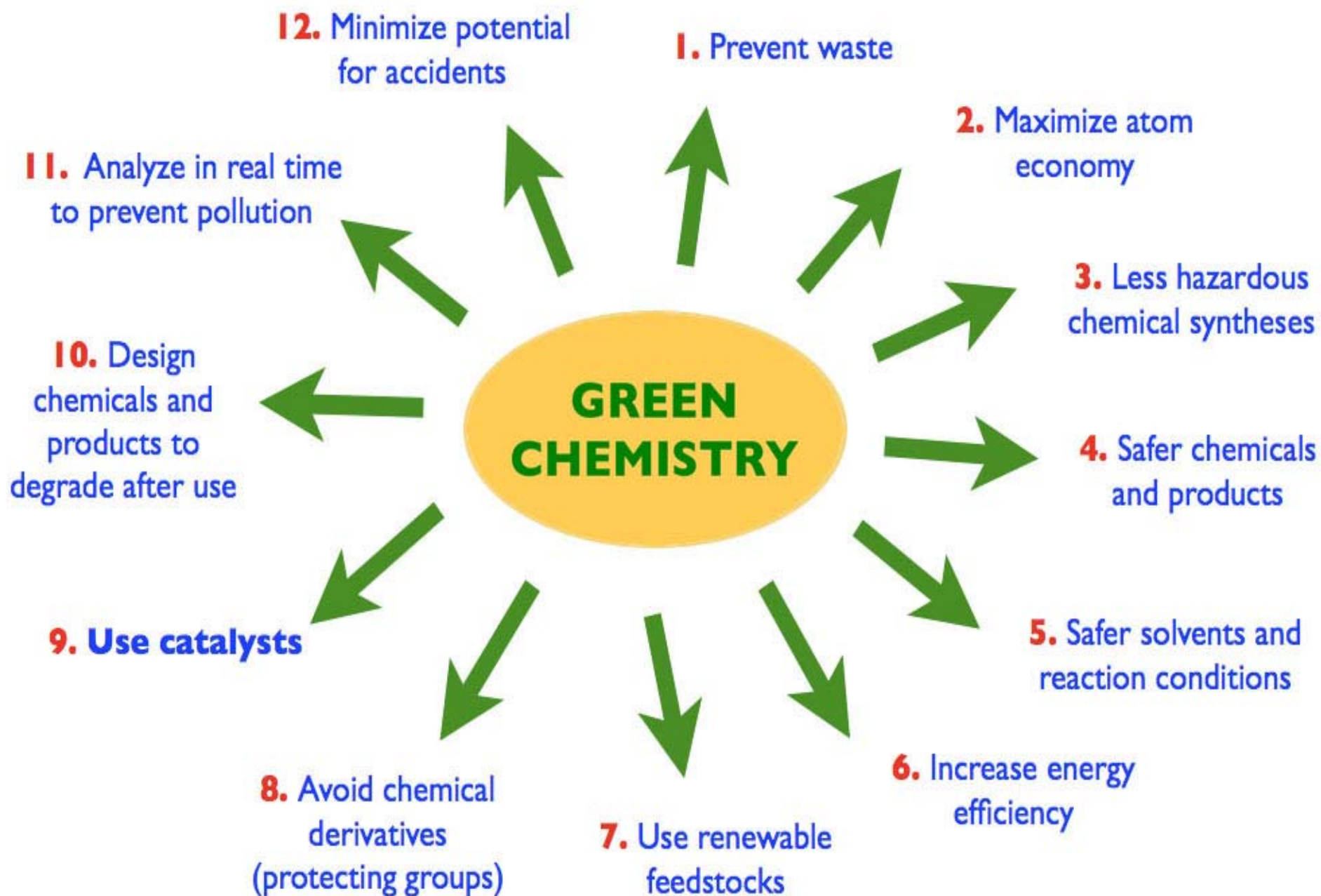


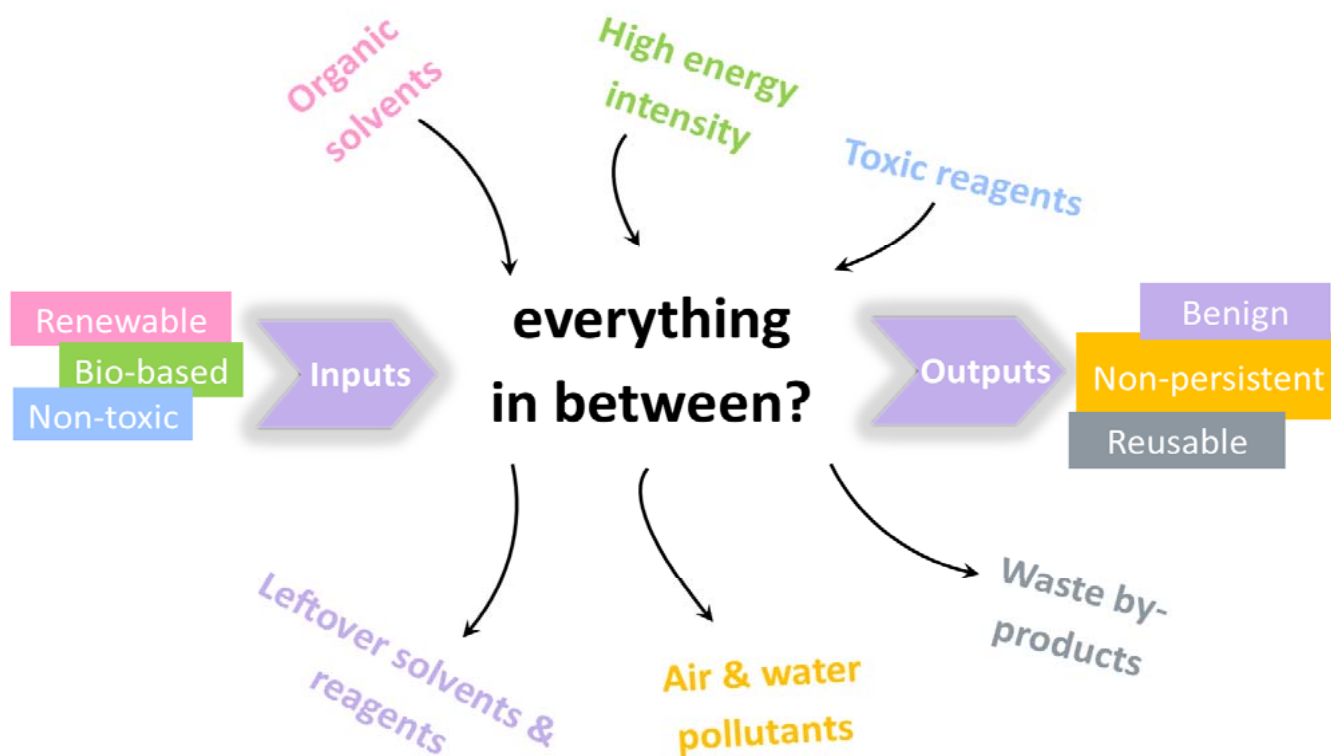
# Solid Waste Management Hierarchy (EPA)





**Green Chemistry = Molecular P2**





Source: Echochem <http://ecochemex.com/tag/sustainable-process-technology/>



# Hazard Reduction

**5 of 12 Principles  
of Green  
Chemistry  
are Focused  
on Hazard  
Reduction**

**#3** Less hazardous chemical synthesis

**#4** Design safer chemicals & products

**#5** Use safer solvents and auxillaries

**#10** Design chemicals & products that degrade after use

**#12** Minimize potential for accidents (using safer chemicals)

# Minimize Risk



$\text{Risk} = f(\text{hazard, exposure})$



# Chemical Risk Management Prioritization

- **Elimination of chemical**
- **Substitution by less hazardous chemical/process**
- Reduce/eliminate release through use of processes & engineering controls
- Collective protection at source of risk
- Personal protection measures

# Hazard = Risk

- **Exposure potential**
- **Uncertainty: exposure pathways**
- **Exposure: usually single component**



# Industry Example

## Segetis (Minnesota)

- High-efficacy solvents from waste wood trimmings and corn stalks
- These solvents now power *Method* cleaners/detergents



**3.** Less hazardous chemical syntheses

**5.** Safer solvents and reaction conditions

**7.** Use renewable feedstocks

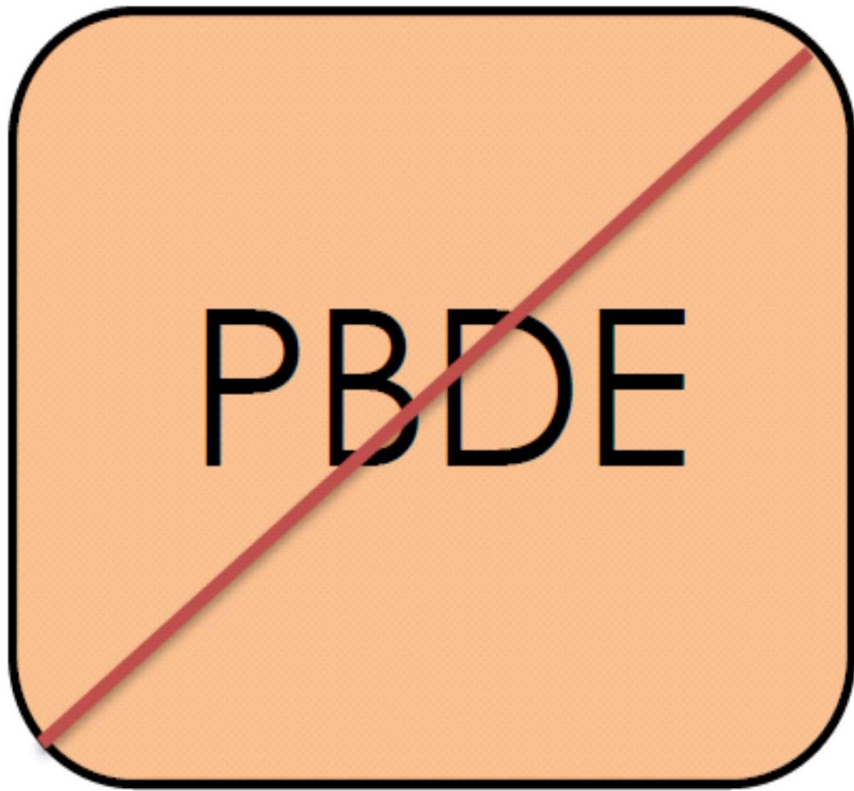
**12.** Minimize potential for accidents

**4.** Safer chemicals and products

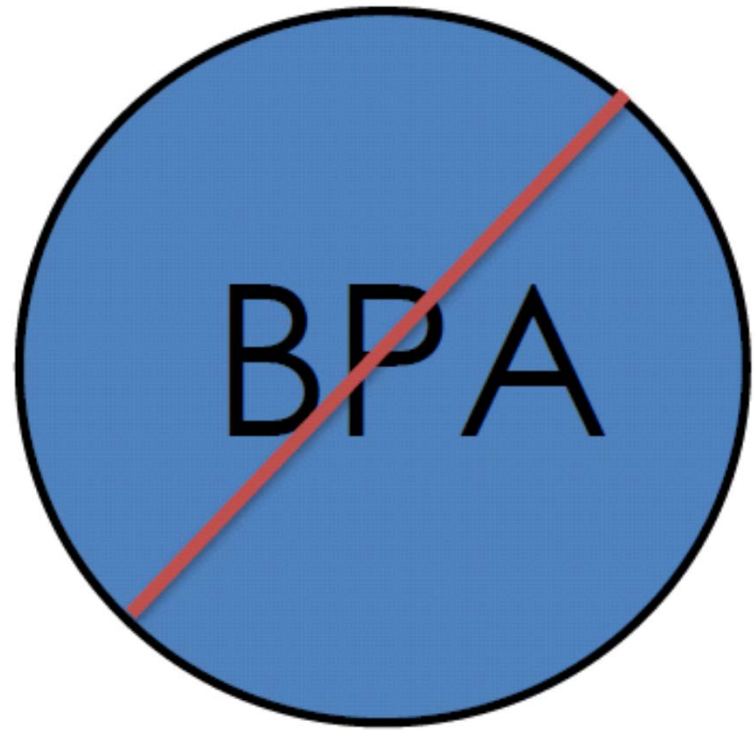
# Drivers for Using Safer Chemicals

- Market position/consumers
- **In-house decisions**
  - Staples, SC Johnson, Walmart, Whole Foods...
- **Regulatory**
  - Domestic
  - EU: REACH (Registration, Evaluation and Authorization of Hazardous Chemicals)

# Company Initiative



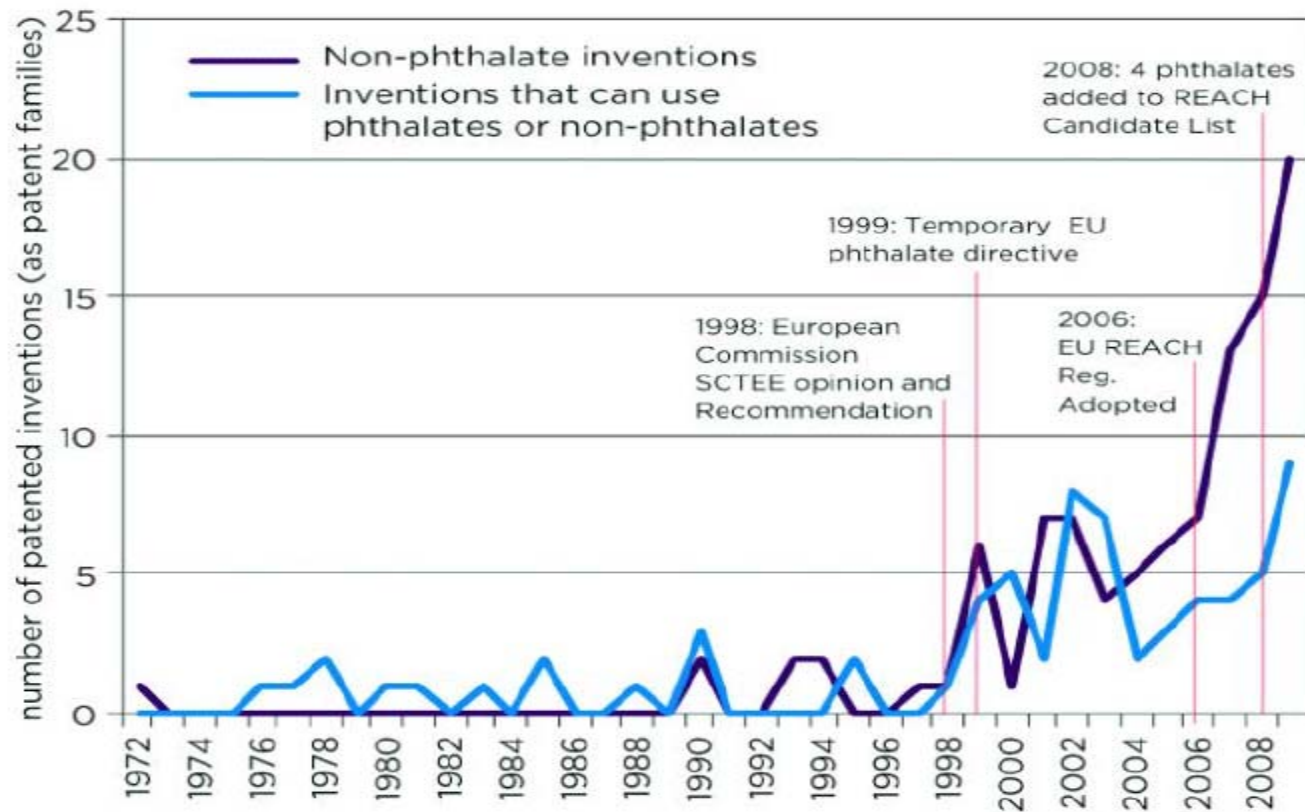
Wal-Mart, 2011



Whole Foods, 2006  
baby bottles, children's cups

# Regulations

**Spike in Patented Inventions Free of Hazardous Phthalates**



Exponential growth in the number of patented inventions for phthalate alternatives beginning in 1999, coinciding with the adoption of stricter rules (as captured by the number of patent families for "non-phthalate" and "phthalate free" inventions)



# Regulations

- USA
  - California
    - **Safer Consumer Product Regulations**
    - Requires companies to submit information on specific known or suspected carcinogens, reproductive toxins and developmental toxins
    - Coca-Cola and PepsiCo stated they would be changing their carcinogenic caramel coloring in products nationwide as a result of California law that requires labels on products containing cancer-causing ingredients\*

\* Elks, J. *Pepsi to Phase Out Cancer-Causing Caramel Coloring*. Sustainable Brands. July 8, 2013.

Kenneth Cole Reaction wallets are handcrafted from the finest materials available. Any markings are a distinct part of the character and texture of the leather which makes each Kenneth Cole Reaction wallet an original.

**CALIFORNIA PROPOSITION 65**

**WARNING:** This product contains chemicals known to the State of California to cause cancer, and birth defects or other reproductive harm.

# Regulations

- USA
  - Washington
    - **Childrens Safe Products Law**
    - Washington required manufacturers to state the amounts of 66 COC found children's products, and published the results on the state's public website.
    - Requires companies to submit information on specific known or suspected carcinogens, reproductive toxins, developmental toxins & endocrine disruptors

# Regulations

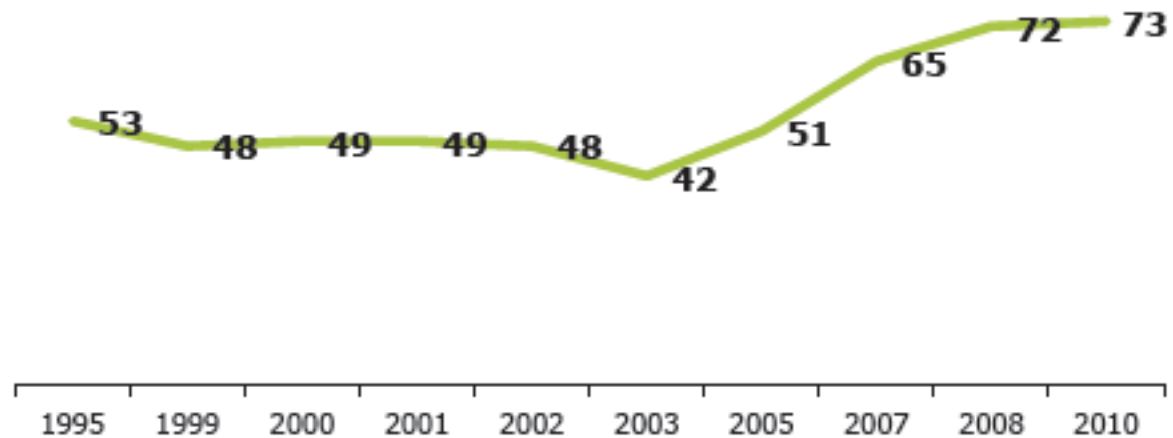
- USA
  - Minnesota
    - Toxic Free Kids Act
      - Identify and communicate the potential for hazardous chemical exposures which could be harmful to human health, particularly to vulnerable or susceptible populations, such as children and pregnant women
      - CVHC & priority chemical lists

# Regulations

- EU
  - REACH (Registration, Evaluation and Authorization of Hazardous Chemicals)
    - Improve the protection of human health and the environment from the risks that can be posed by chemicals
    - Bans/restricts use & importation of hazardous chemicals
    - **Places the burden of proof on companies.** To comply with the regulation, companies must identify and manage the risks linked to the substances they manufacture and market in the EU. They have to demonstrate to ECHA how the substance can be safely used, and they must communicate the risk management measures to the users



— % Who Say They Know A Lot/Fair Amount About  
Environmental Issues and Problems (Total US Population 18+)



Source: The Environment: Public Attitudes & Individual Behavior – A 20 Year Evolution (2011)

THANK YOU



Earth Lights at Night