Green Chemistry & Cradle to Cradle Design: Forging A Path to Sustainable Innovation

Green Chemistry III
Synthesis of Success
Cal/EPA
October 30, 2007

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Senior Fellow
GreenBlue

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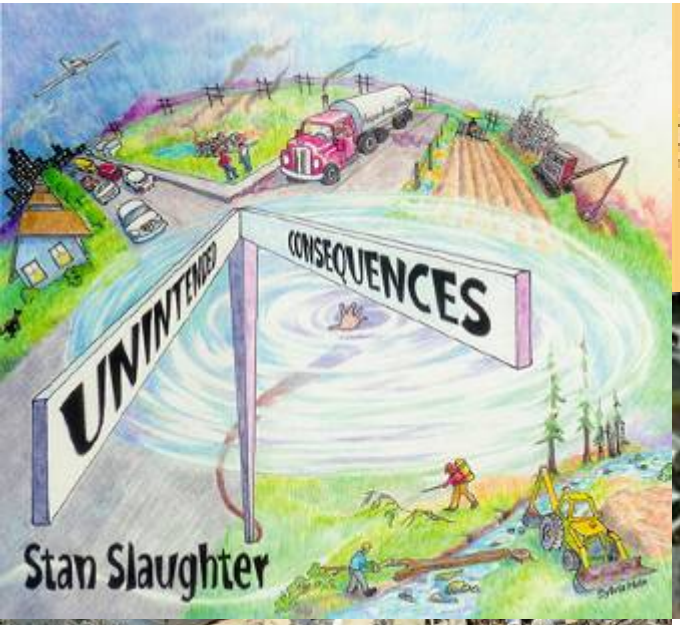
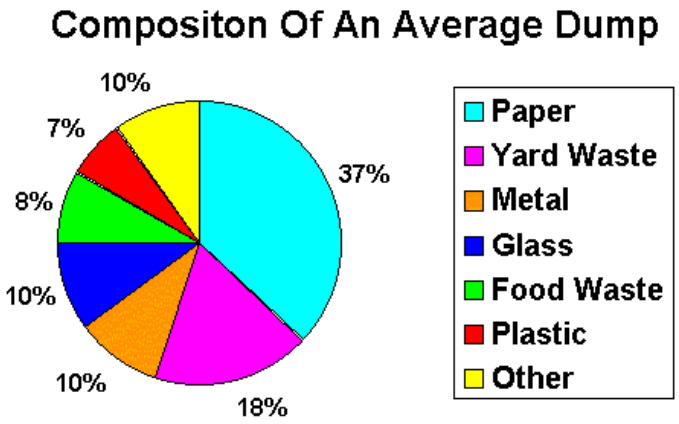
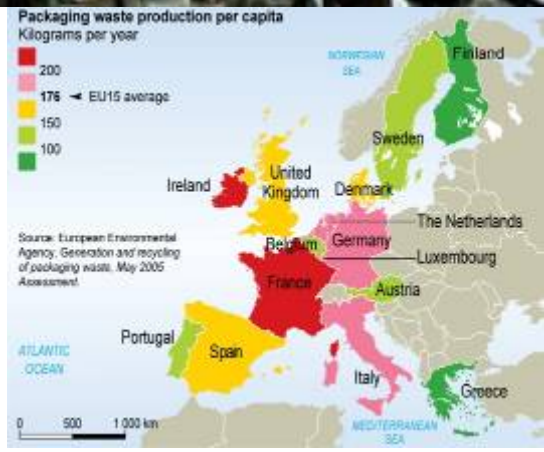
Outline

- Environmental problems and market trends
- Complementary ideas driving innovation
  - Green Chemistry
    - Focuses on reducing hazard
    - Tools and metrics are needed to support companies on the path to green chemistry
    - Existing and emerging tools include:
      - EPA's Design for the Environment Program
      - The Green Screen for Safer Chemicals
      - CleanGredients
  - Cradle to Cradle design
    - Focuses on reducing hazard and
    - Promotes sustainable material flows across a product's life cycle

Mountains (and Rivers) of Waste in the Land of Unintended Consequences







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2ND-QTR SIZZLE
PROFITS AT 900 COMPANIES (P.74)
PAYING FOR COLLEGE
BEWARE OF THOSE HIGH 529 FEES (P.96)
TERRORISM WHAT COMPANIES STILL NEED TO DO (P.26)
The McGraw-Hill Companies
BusinessWeek
www.businessweek.com
GLOBAL WARMING
Why Business Is Taking It So Seriously
BY JOHN CAREY (P.60)

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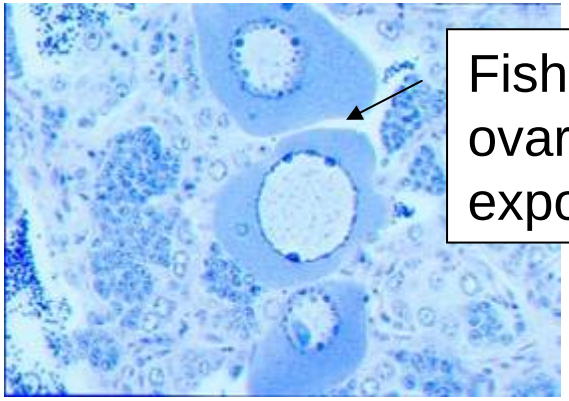
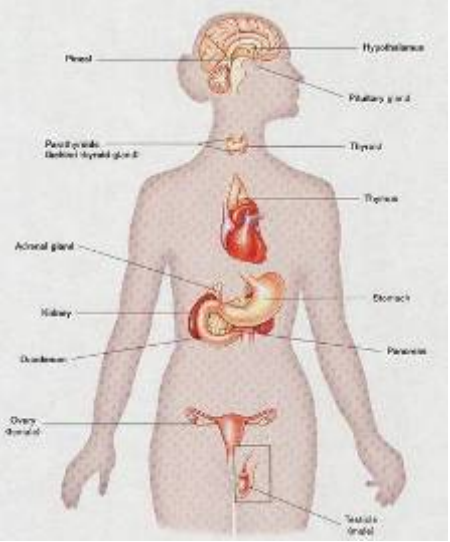
Endocrine Disruptors

- Chemicals that mimic or block the activities of hormones or alter the concentrations of natural hormones
- Examples commonly used in cleaning products
  - Alkylphenol ethoxylates degrade to alkyl phenols
    - Particularly in aquatic and anaerobic environments
    - Nonylphenol found in dust samples in study of homes
  - Some phthalates used in fragrances



Fish testes containing ovarian tissue due to exposure to ED compounds



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“Scientists Drug-Test Whole Cities”

- *“It’s a community urinalysis,” said Caleb Banta-Green, a University of WA drug abuse researcher who was part of the Oregon State team. The scientists presented their results at a meeting of the ACS in Boston (Aug 2007).*
- *“One of the early results of the new study showed big differences in methamphetamine (meth) use city to city. One urban area with a gambling industry had meth levels more than five times higher than other cities. Yet meth levels were virtually nonexistent in some smaller Midwestern locales”, said Jennifer Field, the lead researcher and a professor of environmental toxicology at OSU.*
- *“The ingredient Americans consume and excrete the most was caffeine”, Field said.*

Tamiflu Survives Sewage Treatment

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Growing Consumer Concern About Product Safety: “Which Companies Can I Trust?”

Body Burden testing raises public awareness of chemicals in products :

“*Every single sample of mother or baby blood tested positive for an array of chemicals linked to birth defects or certain types of cancer*.”

http://www.wwf.org.uk/chemicals/biotourbaby.asp

Toy scandal only accentuates consumer concern

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A Growing Green Economy

GreenBiz.com

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News

Green Building Survey Shows 20% Growt
in 2005, 30% in 2006

Source: GreenBiz.com

NEW YORK, May 3, 2006 - Preliminary results of a McGraw-Hi
Construction/National Association of Home Builders (NAHB)
survey indicated that there was a 20% increase in 2005 among
those in the home building community who are focusing their
attention on green, environmentally- responsible building, which
is expected to increase by another 30% this year.

The research findings will be issued May 15 in the Residential
Green Building edition of McGraw-Hill Construction's series of
SmartMarket Reports.

start | 4 Microso...

Showcasing the **Growth** of the **Green** Economy - washingtonpost.com
Ware is one of the owners of Eco-**Green** Living, a Logan Circle store that sells organic and fair-trade **products** such as teas, hemp boots and even the ...
www.washingtonpost.com/wp-dyn/content/article/2006/10/15/AR2006101500685.html - Similar pages - Note this

World Business Council for Sustainable Development (WBCSD)
Around the world, farsighted companies are creating new **green products** and ... That optimism may be the best evidence that the **growth** of **green** policies is ...
www.wbcsd.org/Plugins/DocSearch/details.asp?DocTypeId=32&ObjectId=MjI1MTQ - 72k - Cached - Similar pages - Note this

Winslow **Green Growth** Fund: On the Rise Again
The Winslow **Green Growth** Fund's three-year returns are 19.51 percent ... risk and cost and the impact **green products** have on enhancing revenue **growth**--and ...
www.socialfunds.com/news/article.cgi/1771.html - 27k - Cached - Similar pages - Note this

Green power needs marketing
They constructed low-**growth** and high-**growth** models by studying the actual penetration of **green** power markets to date, by considering the S-shaped "**product** ...
www.lbl.gov/Science-Articles/Archive/**green**Power.html - 13k - Cached - Similar pages - Note this

Green-e Audit Report Reveals Significant Annual **Growth in Green** ...
"With the doubling of certified **products** in 2003, we're looking forward to seeing the next year's results, which should show another **growth** year for **Green**-e ...
www.energyvortex.com/pages/headlinedetails.cfm?id=1027 - 26k - Cached - Similar pages - Note this

[PDF] Forecasting the **Growth** of **Green** Power Markets in the United States
File Format: PDF/Adobe Acrobat - View as HTML
The general pattern of market development among these **green products** and activities has. almost without exception been one of steady but restrained **growth** ...
www.eere.energy.gov/**green**power/resources/pdfs/30101.pdf - Similar pages - Note this

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Wal-Mart's Principles for Preferred Chemical Intensive Products

Safe Products for Mother, Child, and the Environment

- ***When we suspect that an ingredient in a product or the product itself is capable of causing harm to human health and the environment, we will act to find better alternatives.***
- ***We will favor those products that do not contain the following:***

Chemicals Harmful to Human Health **(CMRs)**

- **Carcinogens** – can cause cancer
- **Mutagens** – can damage genetic material
- **Reproductive Toxicants** – may affect reproduction or the unborn

Chemicals Harmful to the Environment **(PBTs)**

- **Persistent** – do not break down in the environment
- **Bioaccumulative** – builds up in the food chain
- **Toxic** – causes death or damage to organisms in the environment

Branding Green Products

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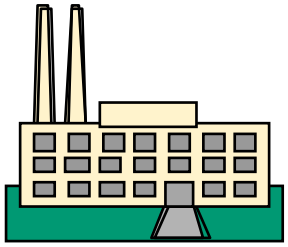
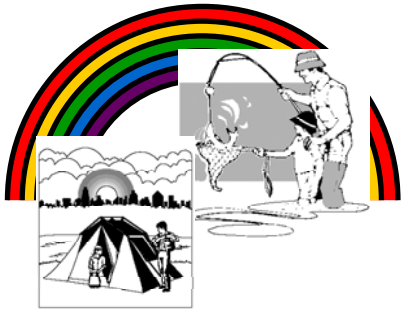
Responsible Organization Trend: Focus on Sustainability





Compliance → **Environment** → **Sustainability**

(Only as good as we are forced to be…)

(ISO 14001)

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Supply Chain Collaboration

SUSTAINABLE PACKAGING COALITION

cleangredients™

the online resource for green formulation

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Emerging Ideas that Drive Innovation*

Green Chemistry and Cradle to Cradle Design

⋮

▼

Innovation

"Fresh thinking that creates value"

(Richard Lyons, Chief Learning Officer at Goldman Sachs)

*From Special Report on Innovation, Oct 13, 2007, *The Economist*

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Green Chemistry: Reducing Risk by Reducing Hazard

Command & Control

- Warning labels
  - How to use it
  - How not to use it
- Regulations
- Chemical bans

or

Benign by Design

- Green Chemistry
- Continual improvement

GREEN CHEMISTRY

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Green Chemistry: Focus on Hazard

Risk = Hazard x Exposure

- Green Chemistry focuses on hazard assessment and continual Improvement, rather than on risk assessment and risk management
- There is a need for tools and metrics to identify safer alternatives (chemicals and processes)

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Promoting Green Chemistry:
USEPA Design for the Environment (DfE) Program Themes

1. ***Informed Substitution:*** *"the considered transition from a chemical of particular concern to safer chemicals or non-chemical alternatives."*
2. ***DfE Motto:*** *"If it's not in your product, you don't have to worry about it."*

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USEPA DfE Hazard Assessment Protocols

L = Low hazard concern
M = Moderate hazard concern
H = High hazard concern
L, M, or *H* = Endpoint assigned using estimated values and professional judgment (Structure Activity Relationships)

N = No
Y = Yes

Chemical	CAS RN	Human Health Effects							Ecotoxicity		Environmental		Potential Routes of Exposure						
													Worker			General Population			
		Cancer Hazard	Skin Sensitizer	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Inhalation	Dermal	Ingestion	Inhalation	Dermal	Ingestion	Aquatic
Phosphoric trichloride, reaction products with bisphenol A and phenol	181028-79-5	*L*	L	*L*	L	*L*	M	L	*H*	*M*	H	*L*	N	Y	Y	N	Y	Y	Y
Phosphoric acid, (1-methylethylidene)di-4,1-phenylene tetraphenyl ester	5945-33-5	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*L*	Y	Y	Y	N	Y	N	N
Phosphoric acid, bis[4-[1-[4-[(diphenoxyphosphinyl)oxy]phenyl]-1-methylethyl]phenyl] phenyl ester	83029-72-5	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*L*	Y	Y	Y	N	Y	N	N
Triphenyl Phosphate	115-86-6	*L*	L	L	L	L	M	L	H	*H*	L	L	Y	Y	Y	Y	Y	Y	Y
Phosphoric trichloride, polymer with 1,3-benzenediol, phenyl ester	125997-21-9	*L*	L	L	L	*L*	M	L	*H*	*M*	L	*M*	Y	Y	Y	Y	Y	Y	Y
Phosphoric acid, 1,3-phenylene tetraphenyl ester	57583-54-7	2.	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*H*	*L*	*M*	Y	Y	Y	N	Y	N	N
Phosphoric acid, bis[3-[(diphenoxyphosphinyl)oxy]phenyl] phenyl ester	98165-92-5	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	Y	Y	Y	N	Y	N	N
Triphenyl Phosphate	115-86-6	*L*	L	L	L	L	M	L	H	*H*	L	L	Y	Y	Y	Y	Y	Y	Y

See *Environmental Profiles of Chemical Flame Retardant Alternatives for Low Density Polyurethane Foam* at:
http://www.epa.gov/dfe/pubs/flameret/ffr-alt.htm

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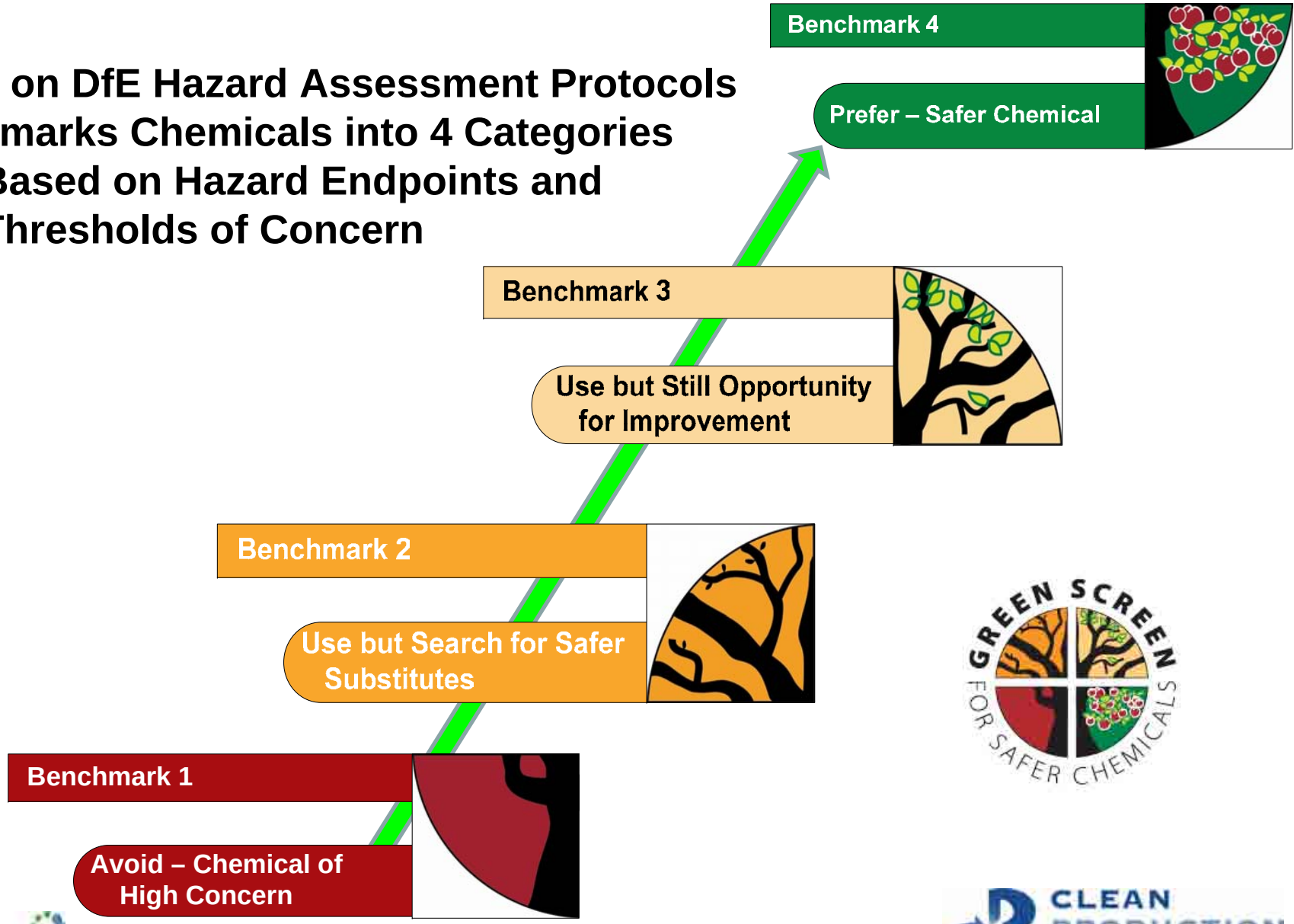
Design for the Environment U.S. EPA

The Green Screen for Safer Chemicals

- Builds on DfE Hazard Assessment Protocols
- Benchmarks Chemicals into 4 Categories
  - Based on Hazard Endpoints and
  - Thresholds of Concern



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CLEAN PRODUCTION ACTION

Think of it as a way for a manufacturer of chemical intensive products to improve his/her golf game…and lower their handicap.

Benchmark 4

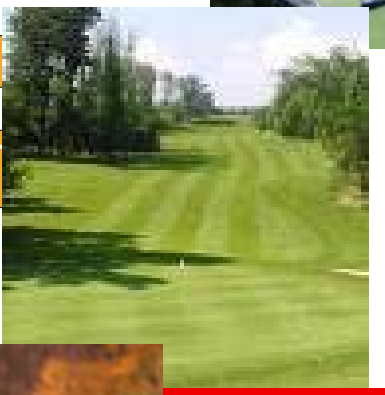
Prefer – Safer Chemical

Benchmark 3

Use but Still Opportunity for Improvement

Benchmark 2

Use but Search for Safer Substitutes



Benchmark 1

Avoid – Chemica
High Concern

You really want to blast your way
out of this hazard! – and get back on course

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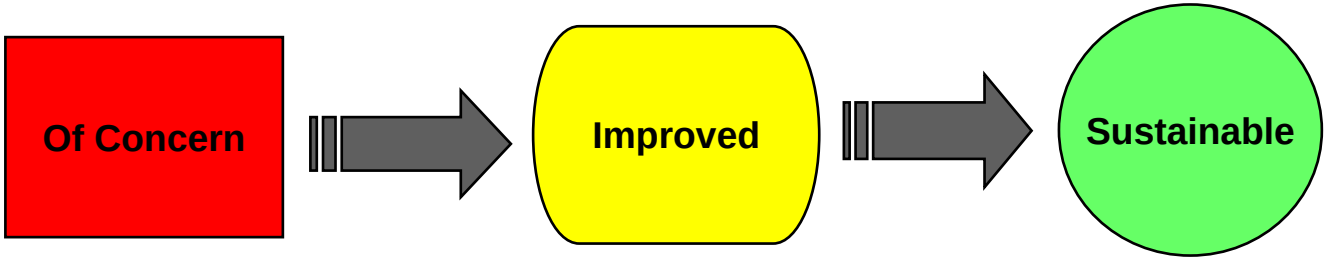
CLEAN PRODUCTION ACTION

US EPA DfE Formulator Program

When you see the DfE logo on a product, what does it mean?

It means that the DfE technical workgroup has screened each ingredient in the product for potential human health and environmental effects and that—based on currently available information, predictive models, and expert judgment—the product contains only those ingredients that pose the least concern among chemicals in their class.



Characteristics of Ingredient of Concern

Characteristics of Improved Ingredient

Characteristics of Sustainable Ingredient

US EPA DfE Formulator Program

#1 Formulator Question

Is there a list of safer chemicals we can use in making our ingredient choices?

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the online resource for green formulation

a project of GreenBlue

sponsored by Design for the Environment U.S. EPA, ISSA The Experts on Cleaning and Maintenance, EcoLogo, Reckitt Benckiser, Henkel, Corporate Express

CleanGredients™:

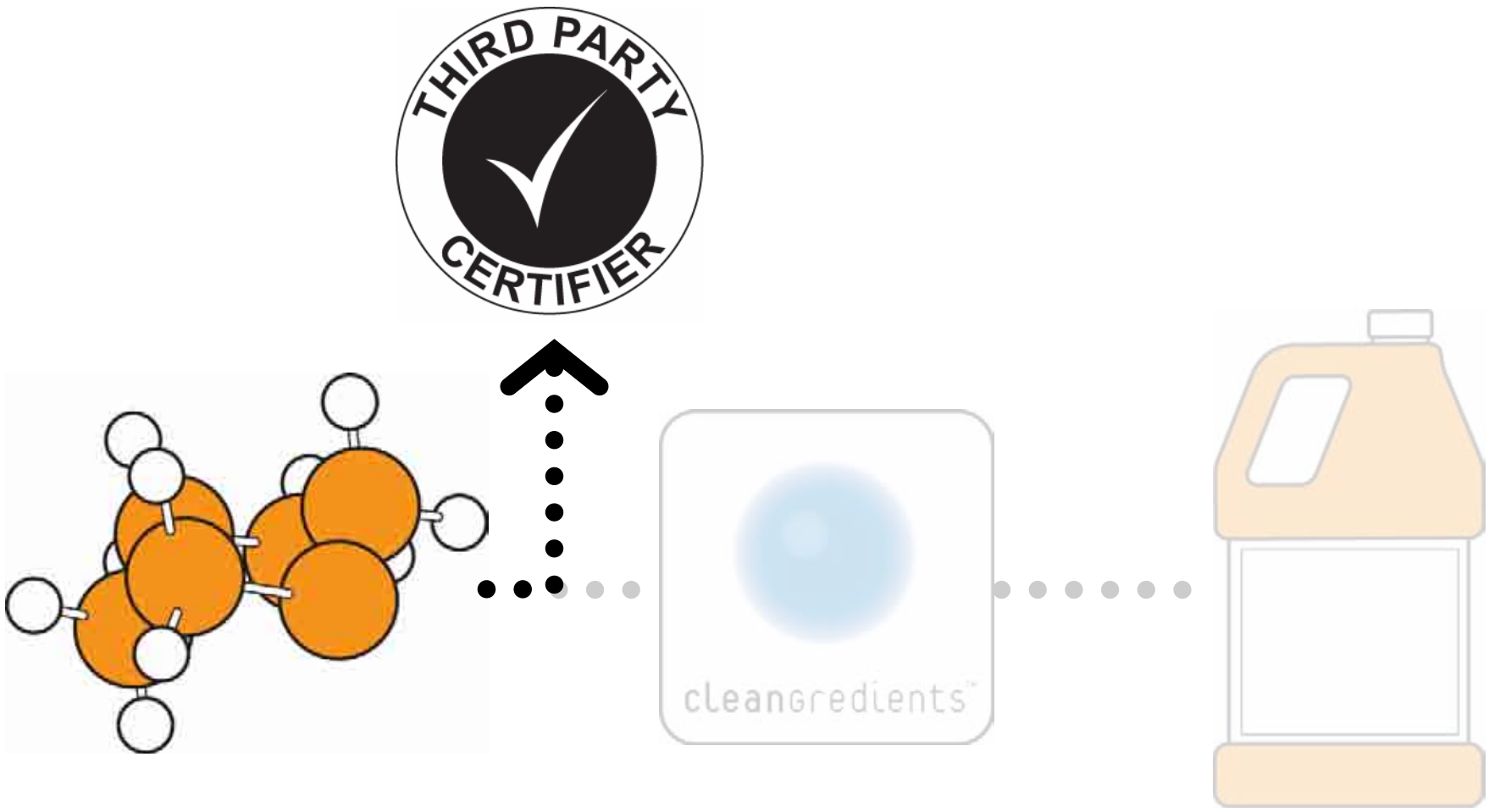
A database of Industrial & Institutional (I&I) cleaning product ingredients and their characteristics* to:

- **help formulators identify ingredients that may be useful for green product formulation**
- **provide opportunity for raw material suppliers to showcase their ingredients with especially positive environmental and/or human health and safety attributes**

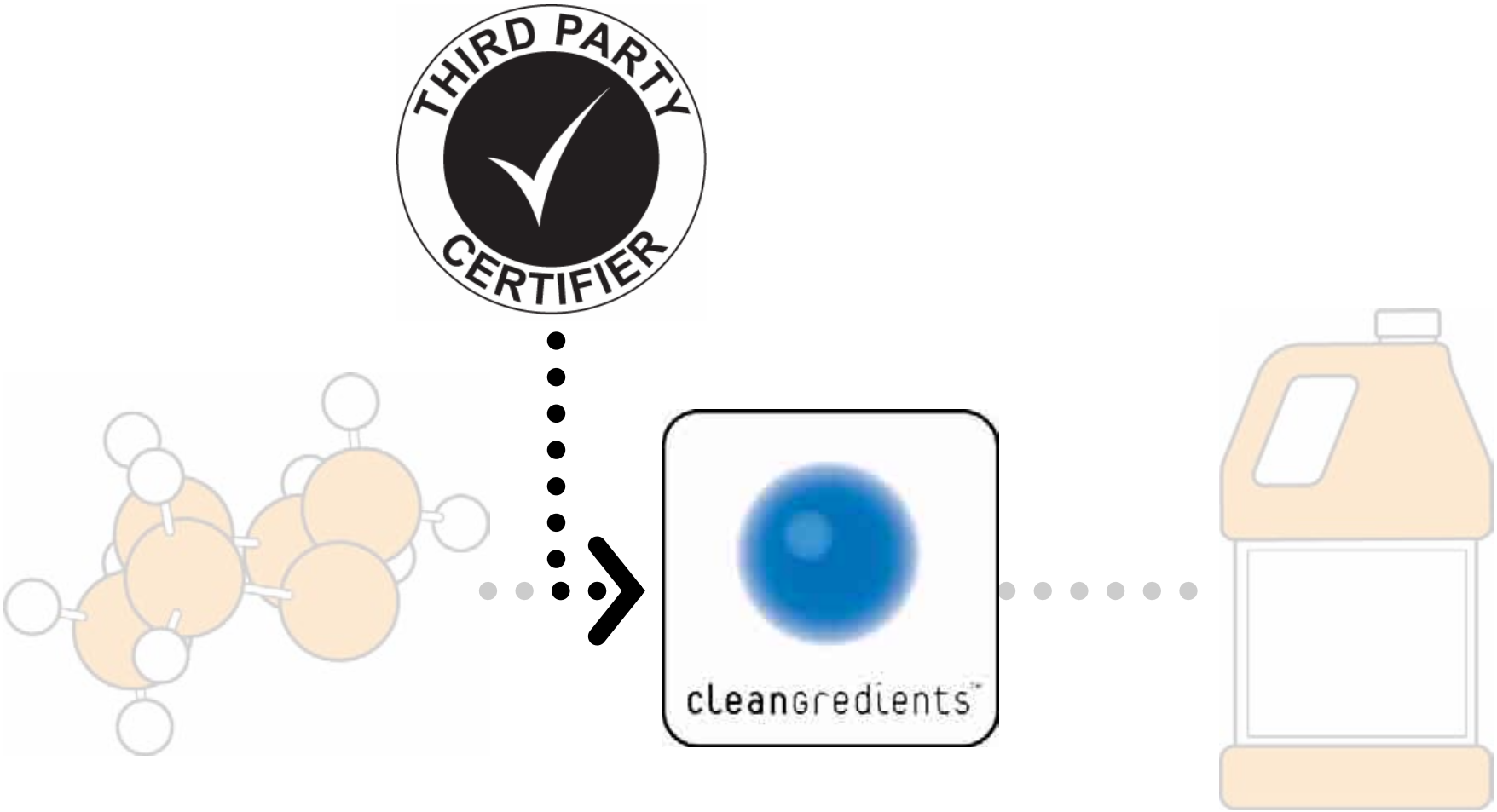
* By ***characteristics*** we mean functional properties such as critical micelle concentration, physical properties such as biodegradability, and associated human and environmental health toxicological information.

How it works...

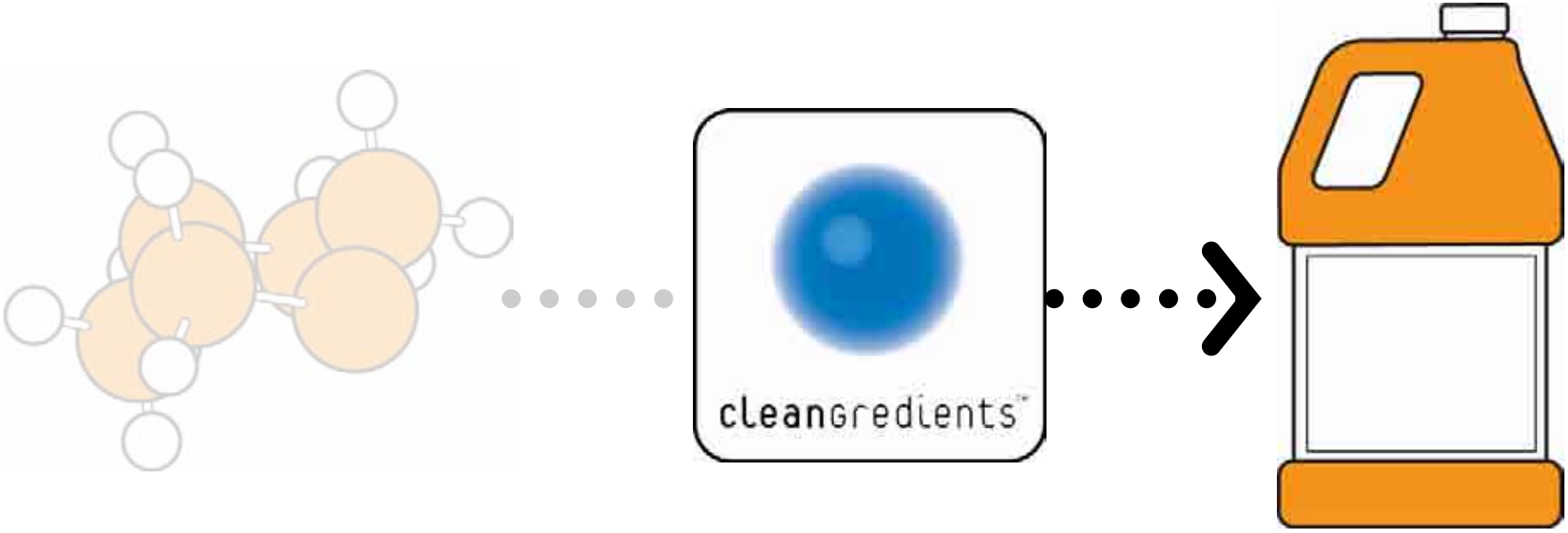
Suppliers submit ingredient formulation and data to a **third-party** under confidentiality



Third-party reviewer enters Tier 1 data into CleanGredients and indicates whether ingredient passes the DfE Screen



Formulators search CleanGredients and select ingredients for use in products



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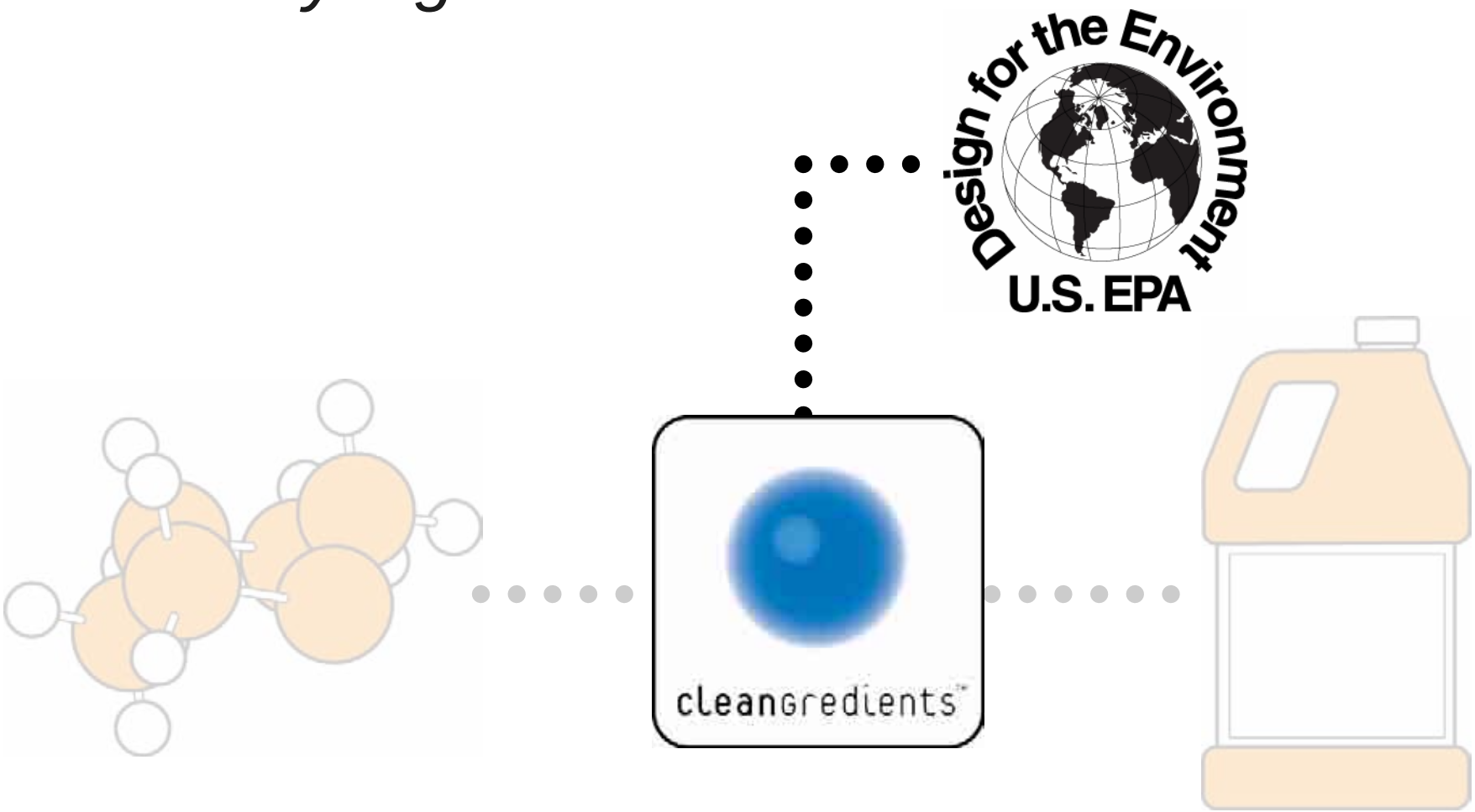
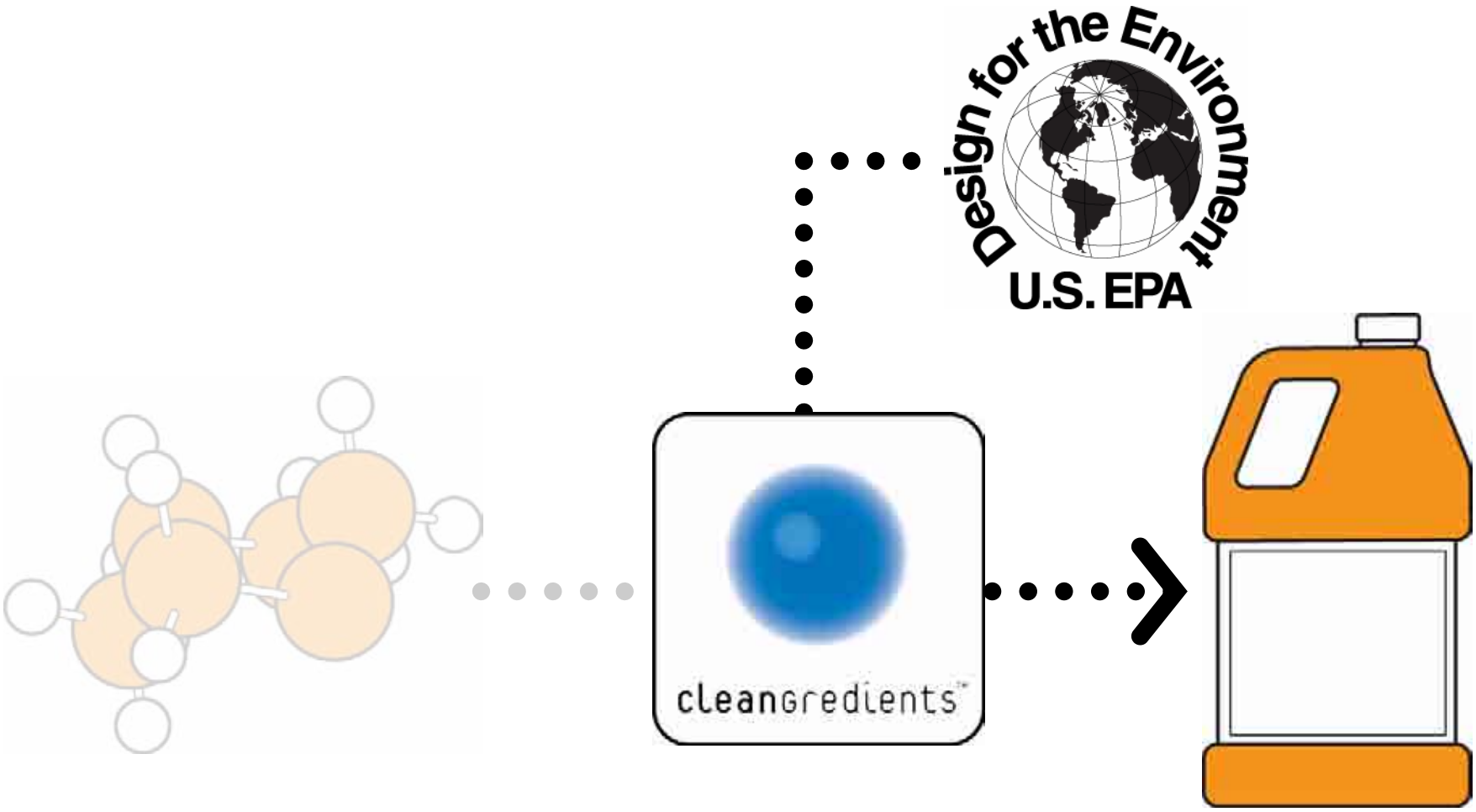
For formulators who seek U.S. EPA DfE recognition...

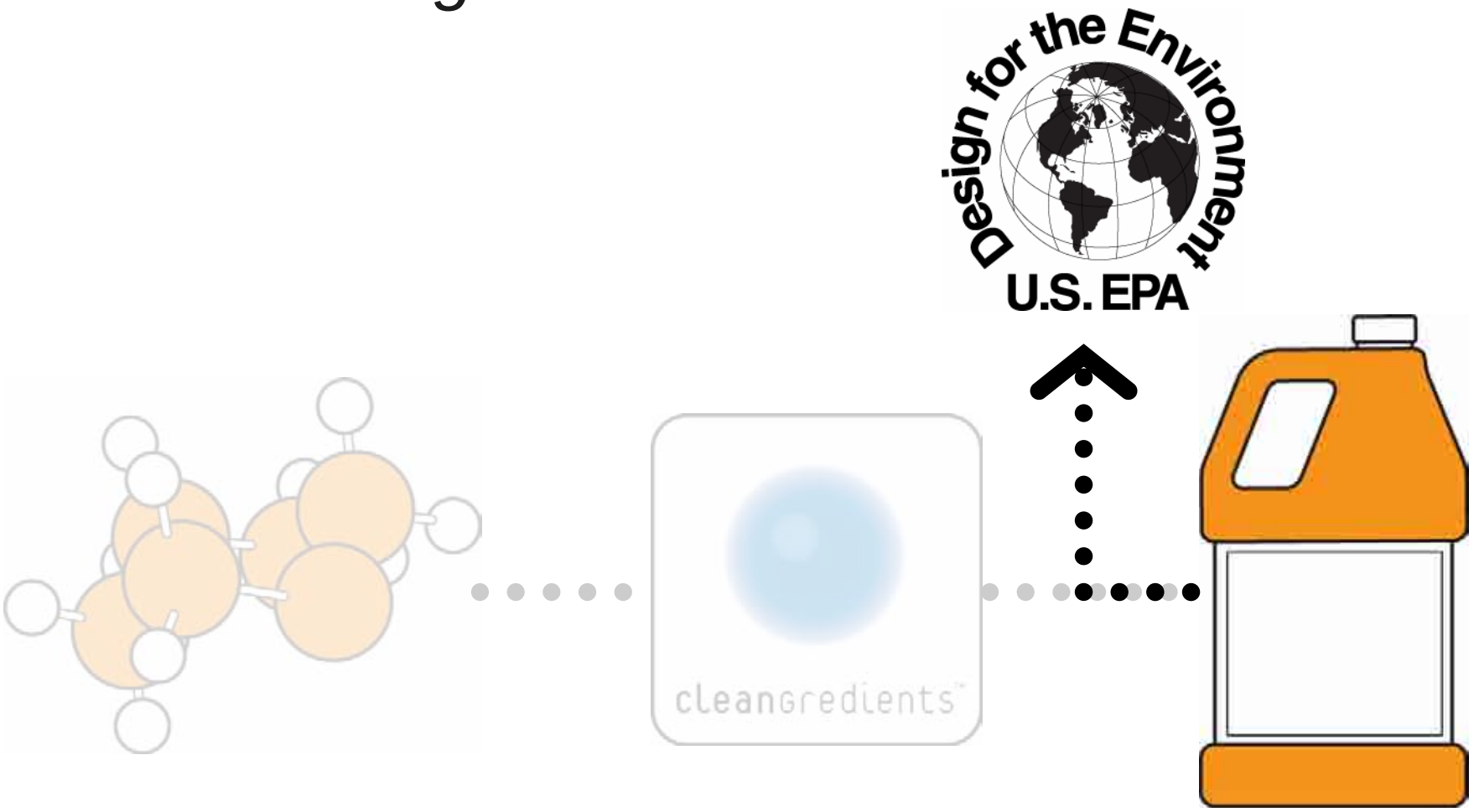
EPA DfE provides a “screen” to identify preferred ingredients. *Ingredients that pass the DfE Screen reach a very high bar.*



Formulators use the DfE screen to select ingredients for products



Formulators submit information about products for review by EPA DfE. *Costs are lowered using pre-reviewed ingredients*.



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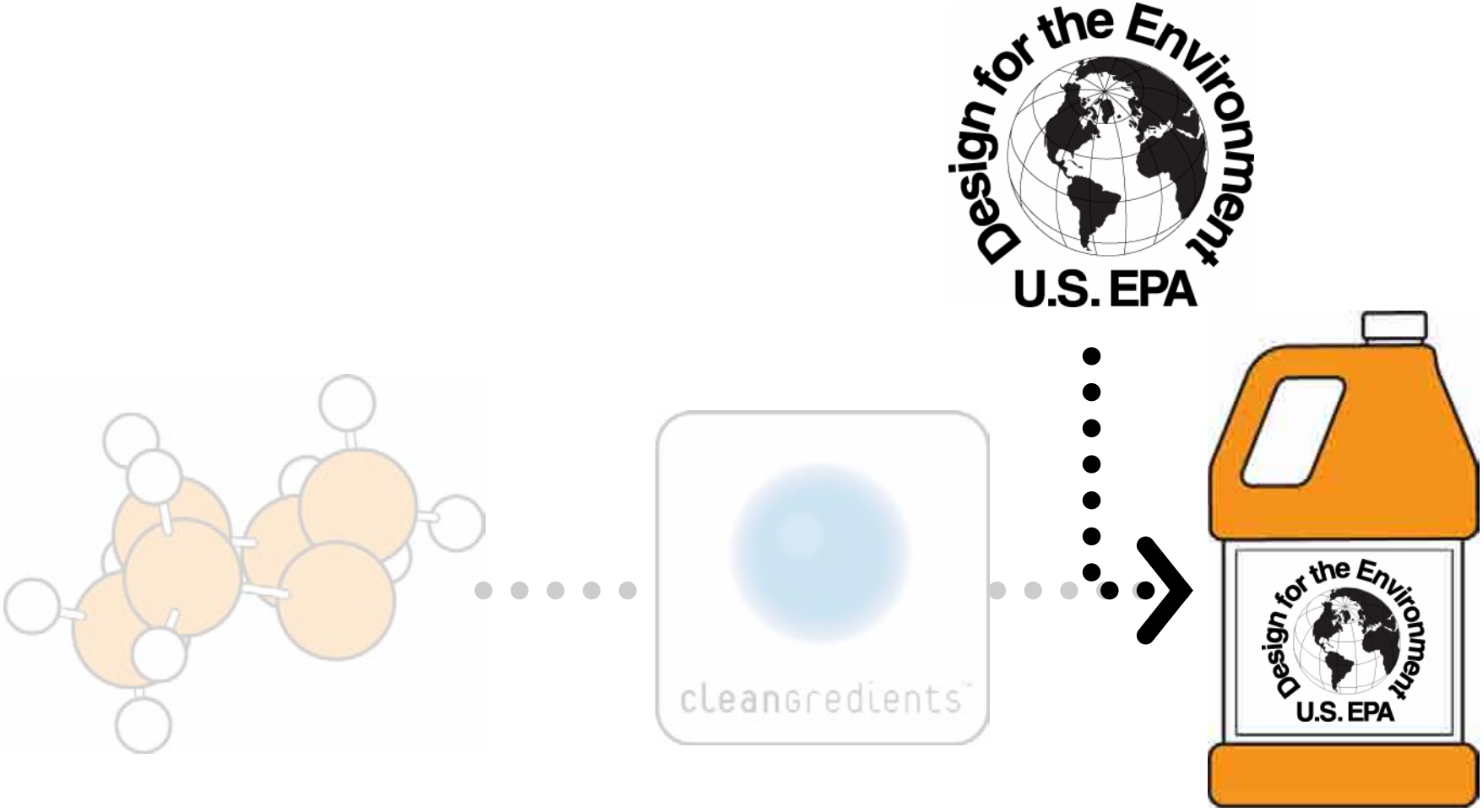
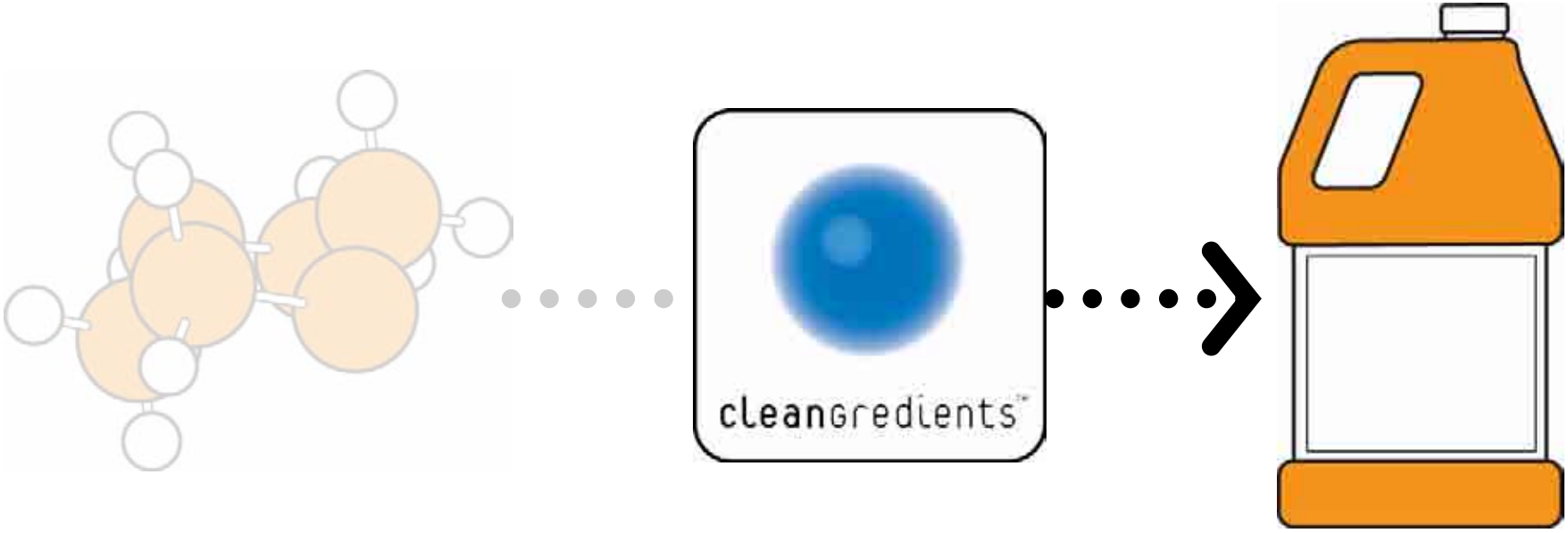
U.S. EPA recognizes products that meet DfE criteria based on product ingredient review

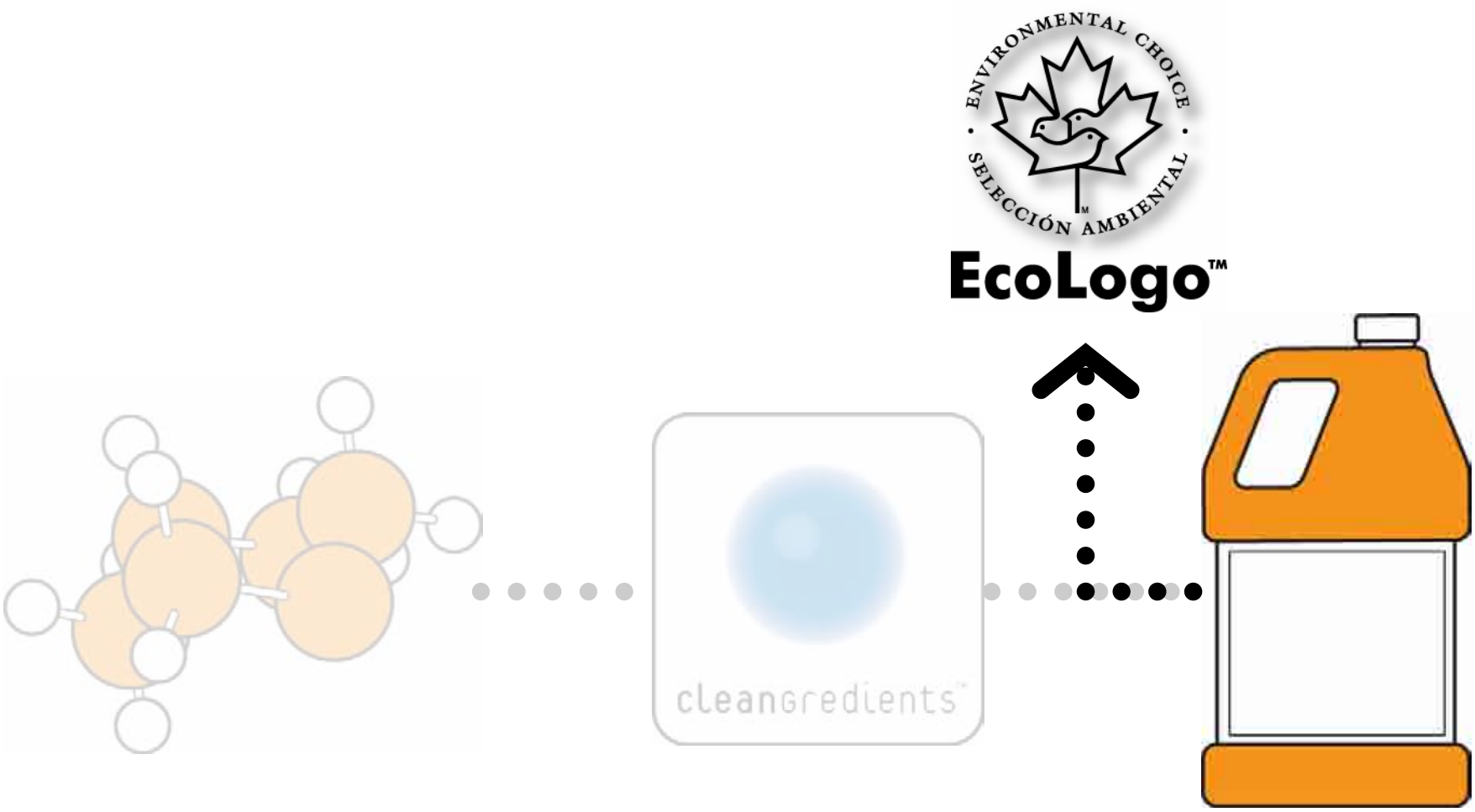


For formulators who seek eco-label recognition...

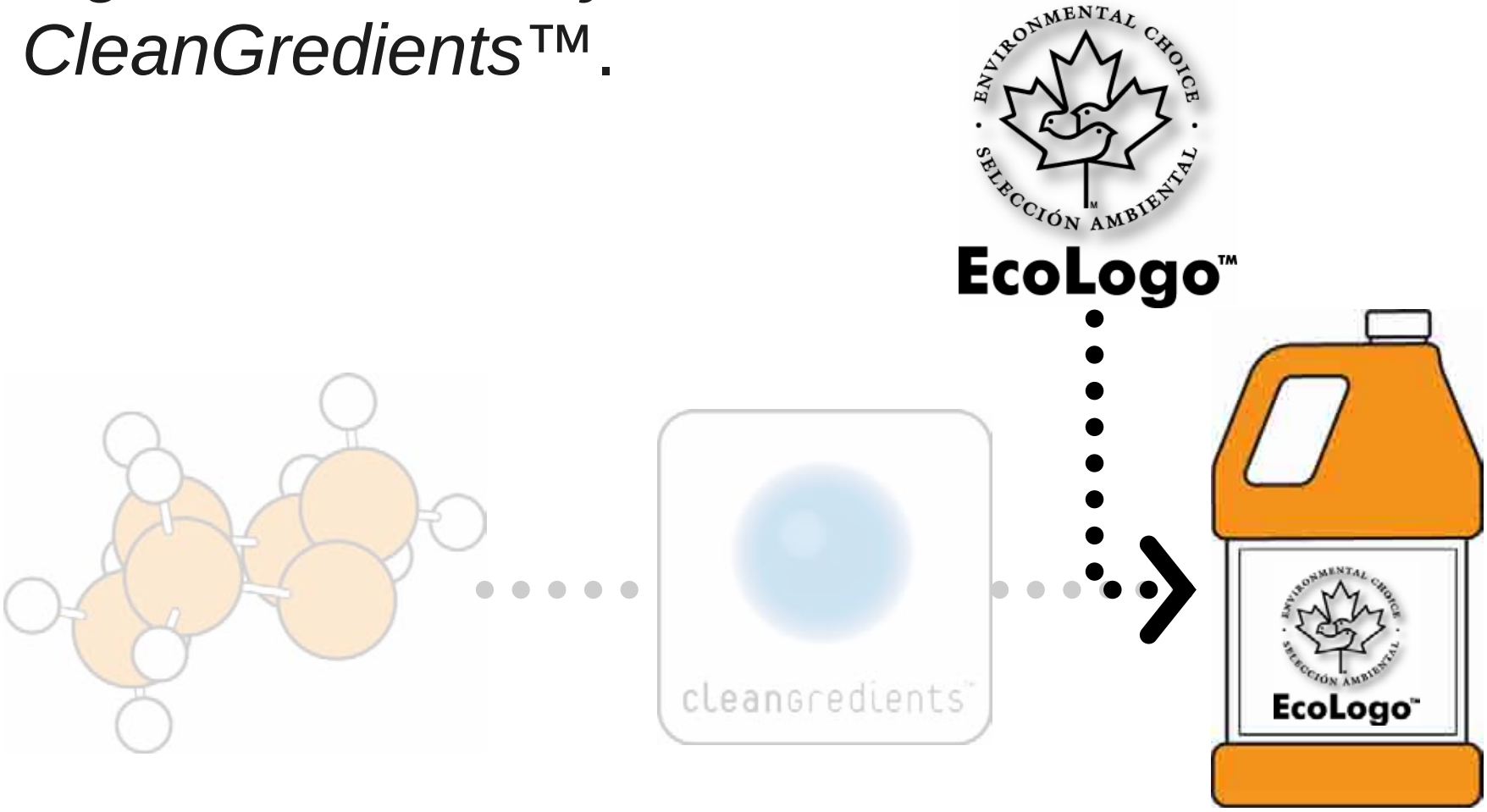
Formulators select ingredients with supporting information for use in new products



Formulators submit information about products to eco-labeling organizations



Eco-labeling organizations recognize products that meet their criteria. *Ecolabelers may recognize the validity of data for ingredients listed in CleanGredients™.*



Tier Structure for Ingredient Information

Tier 1 Attributes

- Require the submission of test data for third-party review
- Key attributes for determining whether or not an ingredient will support environmentally preferable product formulation

Tier 2 Attributes

- Required if known and self-reported
- Also important for characterizing ingredients for environmentally preferable product formulation but do not require third-party review

Tier 3 Attributes

- Voluntary
- Information that supports broader environmental perspectives, such as origin of feedstock, life cycle assessments, risk assessments, etc.

Tier 4 Attributes

- Not recommended for inclusion at this time

General Product Information (Surfactants)

Company Information

- Company Name
- Web Address
- Contact and Sales Information

Ingredient Information

- Product Name
- Product Description and Suggested Applications
- Charge Class
- Chemical Classification
- Material Safety Data Sheets, Technical Fact Sheets, Handling and Storage Directions
- Compliance with EU Detergent Directive

Physical-Chemical Properties

- Physical Form
- % Active Surfactant
- Hydrophile-Lipophile Balance (HLB)
- Density/Specific Gravity
- Cloud Point
- Flash Point
- Critical Micelle Concentration
- Surface Tension

Environmental & Human Health Information

Tier 1 Surfactant Attributes

- Acute Aquatic Toxicity (Fish, Daphnia, Algae)
- Biodegradability
  - Consideration of degradation products

Tier 2 Surfactant Attributes

- Sensitization
- Irritancy
- Acute Mammalian Toxicity (Oral, Dermal)
- VOC Content
- Presence of APEs

Tier 3 Surfactant Attributes

- Life Cycle Assessments
- Risk Assessments
- Endocrine Disruption test data
- Additional Aquatic Toxicity (Microtox, Chronic)
- Other Product Features
- Origin of Feedstock

Search by Performance/Physical Properties

https://db.cleangredients.org - CleanGredients™ » Surfactant Search - Mozilla Firefox

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Logged in as Topher Buck from TestCorp.
Log out

search your account

Charge Class	Application	Supplier	Text
All	☐ Hard Surface Cleaner ☐ Hand Dish Soap ☐ Carpet ☐ Laundry	All	
Chemical Class	**CAS #**	**Biodegradability**	**Aquatic Toxicity**
All	All	All	All
HLB	**Physical Form**	**Flash Point**	**CMC**
Min: Max:	All	Min: Max: °C	Min: Max:
% Active Surfactant	**Sp. Gr. or Density**	**Cloud Point**	**pH**
Min: Max:	Min: Max: Sp Gr	Min: Max: °C	Min: Max:

Hide Advanced Options Search Reset

Disclaimer: Only data on acute aquatic toxicity, biodegradability, and degradation products are reviewed by a designated third party for purposes of listing in the CleanGredients(tm) database. All other data and product information are provided by ingredient suppliers who are individually responsible for the accuracy of the information. All TestCorp and GreenBlue Ingredients are fictional and are provided for demonstration purposes only.

If you experience technical difficulties or have any suggestions or comments, please let us know at info@cleangredients.org

Search Results

https://db.cleangredients.org - CleanGredients™ » Surfactant Search - Mozilla Firefox

Supplier	Product Name ID	Charge Class Chemical Class HLB / Form / Flash / CMC %Act / Sp. Gr / Cloud / pH	Biodeg-radability	Acute Aquatic Toxicity L/I/EC_{50} [mg/L]	DfE Screen†
Uniqema	**Monatrope 1620**	Nonionic Alkyl Polysaccharide - / Liquid / 149°C / - 70% / 0.98 / - / 7	**Ready**	**>10 and ≤100**	**Meets DfE Screen**
Air Products & Chemicals (Tomah Products)	**Tomadol 400**	- - 8.9 / Liquid / 123.9°C / - 98% / 0.93 / - / -	**Ready**	**≤1**	**Meets DfE Screen**
Cognis Corporation	**Glucopon 625 UP**	Nonionic Alkyl glucosides 12 / Liquid / >100°C / 0.003 50% / 1.1 / >100°C / 12	**Ready**	**>1 and ≤10**	**Meets DfE Screen**
	Magnesium lauryl sulfate 3097-08-3 (CAS #)	Anionic Linear alkyl sulfate - / - / - / - - / - / - / -	**Ready**	**>10 and ≤100**	**Meets DfE Screen**
Stepan Company	**BIO-SOFT® N1-5** PF696	Nonionic Alcohol Ethoxylates 11.2 / Liquid / >94°C / - 100% / 0.971 / 18°C / 7.2	**Ready**	**>1 and ≤10**	**Meets DfE Screen**
CLER	**LAS** CLER Standard	Anionic Linear alkylbenzene sulfonate, sodium salt - / Solid / - / 0.1 100% / 1.06 / - / -	**Ready**	**>1 and ≤10**	**Meets DfE Screen**

Detailed Ingredient View

https://db.cleangredients.org - CleanGredients™ » View Ingredient - Mozilla Firefox

uniqema

Monatrope 1620

Company Website

General Ingredient Information

Charge Class	Nonionic
Chemical Class	Alkyl Polysaccharide
Product Description	Monatrope 1620 is a bio-based natural renewable alkyl polysaccharide surfactant with a range of properties required in an increasing number of formulations.
Applications	Hard Surface Cleaner Hand Dish Soap Carpet Laundry
Suggested Uses	Ready biodegradible High electrolyte stable Non-gelling super concentrates Excellent hydrotrope Soluble in high alkaline solutions Good wetter and detergent base
EU Detergent Directive Compliance	Yes
EU Detergent Directive Reference	StatementDetRegUpdateUS82006.pdf - 25.75 KB
MSDS File	MSDS16209-2006.pdf - 23.81 KB
Technical Data File	Monatrope 1620.pdf - 1.44 MB

HEHS Considerations into Product Design Process

https://db.cleangredients.org - CleanGredients™ » View Ingredient - Mozilla Firefox

Environmental Summary (Ingredient-Level)

DfE Screen	Yes

Tier I

Tier I Ingredient Attributes require the submission of test data and third party review. More Info.

Acute Aquatic Toxicity Show Details

Reviewed Category	>10 and ≤100 mg/L
Fish LC_{50}	>100 mg/L
Daphnia EC_{50}	10-100 mg/L
Algae IC_{50}	10-100 mg/L

Biodegradability Show Details

Reviewed Category	Readily Biodegradable
Percent Degraded	≥60%
Duration	28 days
	Meets 10-day window
Toxic / Persistent Degradation Products	No

Response

- Launched first module (surfactants) in October 2006
- Current subscribing companies (October 2007)
  - 128 product formulators, 13 surfactant raw material suppliers
- Viewed favorably by industry as providing access to new markets
- Entry costs are low
- Designed via multi-stakeholder process using industry language and addressing multi-stakeholder concerns
- Beta version for solvents complete
- Modules for chelating agents and fragrances under development

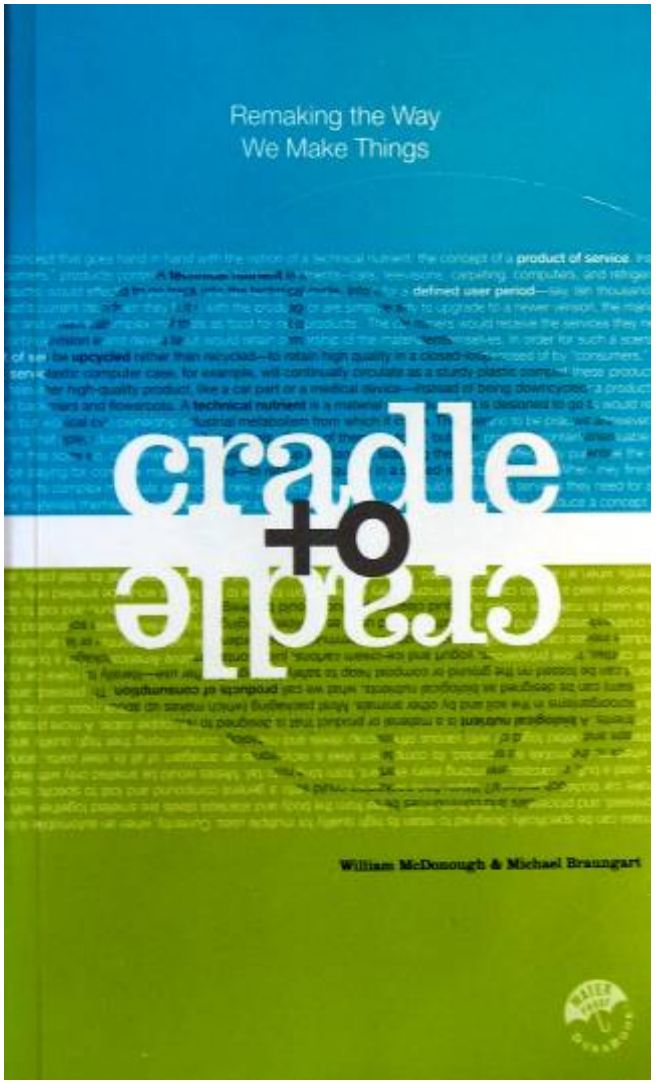
http://www.cleangredients.org/about/subscription/subscribers

“Cradle to Cradle” Design

GreenBlue

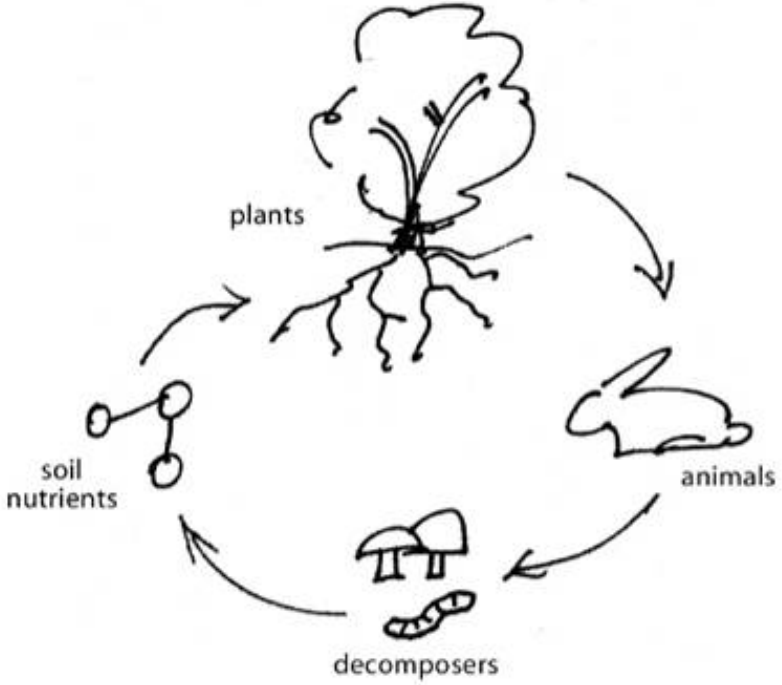
“Cradle to Cradle” Design

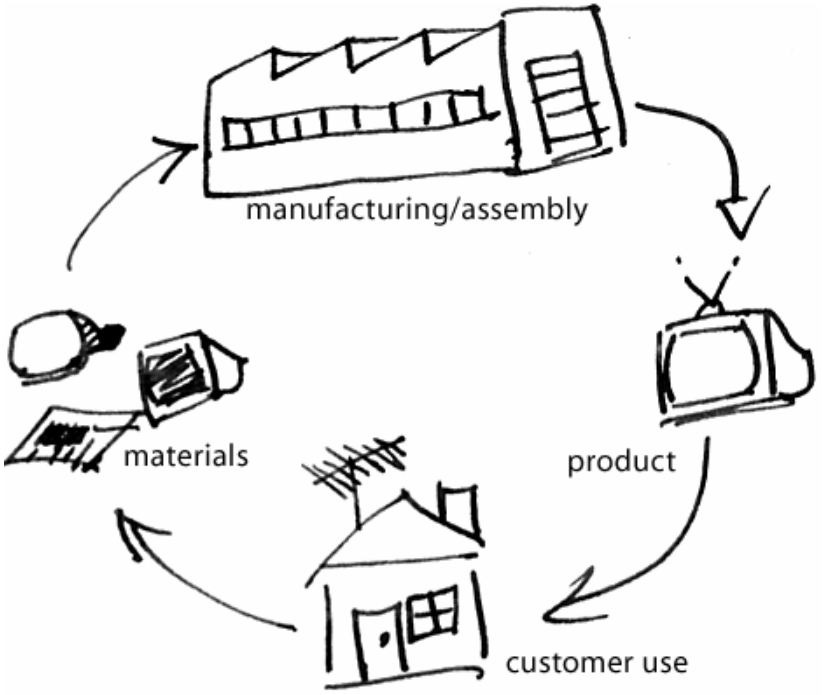
- **Use current solar income**
- **Celebrate diversity**
  - **Of people, products, geographies, cultures, needs and designs**
- **Waste equals food**



GreenBlue

Cradle-to-Cradle Design:
Focus on Nutrients and Metabolisms





GreenBlue

Cradle-to-Cradle Design:
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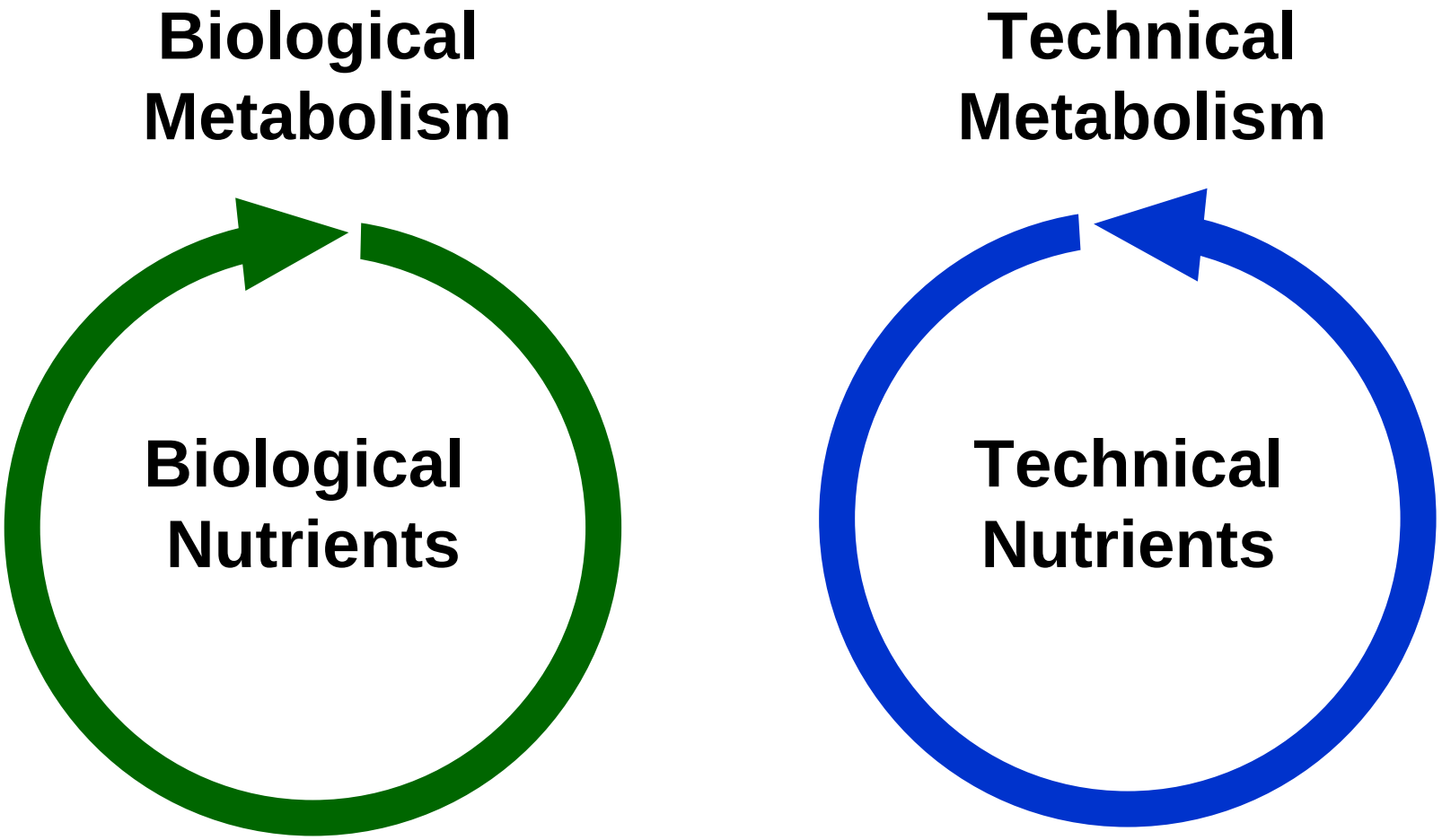

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Green Chemistry & Cradle to Cradle Design Need Robust "Metabolisms"

- **Metabolisms dictate the design parameters for products**
  - **When should investment in innovative treatment technologies (ie metabolisms) be used to address chemical hazard issues?**
    - **i.e., dealing with the limitations of wastewater treatment for removing pharmaceuticals from wastewater – an impact for which green chemistry may not be effective in the near term.**
  - **How can products and material flows be optimized for their highest value recovery?**
    - **Recycling**
    - **Composting or other biological treatment**
    - **Use as alternative fuels and resources (AFR)**
    - **How would these products be identified and recovered?**

Definition of a Sustainable Product*

- **Meets market requirements**
- **Positive social effects (for individuals and communities)**
- **Safe for human and ecological health**
- **Sourced from renewable or repeatedly recycled materials**
- **Sourced from renewable energy**
- **Designed for safe, productive return to nature or industry**
- **Recovered and recycled at its highest quality after use**

* Based on the *Definition of Sustainable Packaging* developed by the Sustainable Packaging Coalition (www.sustainablepackaging.org).

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What are you doing?

- **Sanding marble**
- **Setting a foundation**
- **Building a cathedral (temple, mosque)**

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www.greenblue.org

www.cleangredients.org

www.sustainablepackaging.org