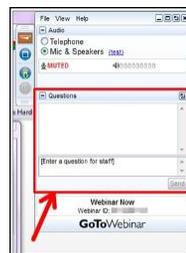
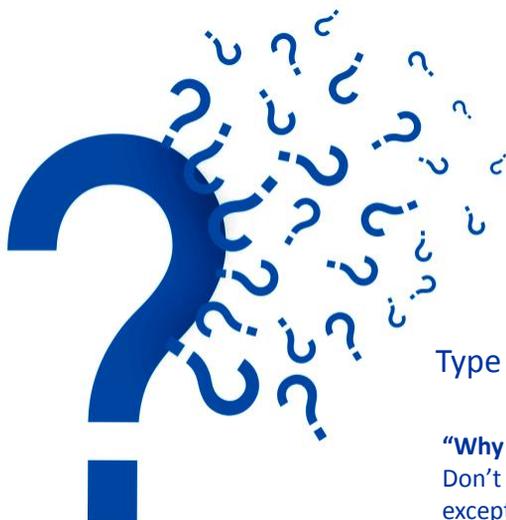


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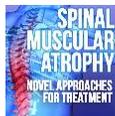


***What Makes Wine Tick: Key Reactions that Create this
Delightful Beverage***

Andrew Waterhouse, University of California, Davis

Bill Courtney, Washington University

Thursday, September 28, 2017



***Spinal Muscular Atrophy: Novel Approaches for
Treatment***

Co-produced with ACS Medicinal Chemistry Division and AAPS

Kevin Hodgetts, Harvard Medical School

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10



How to Create Sustainable Product Design that Satisfies Production Demand and Eco-Awareness



Eric Beckman
Entrepreneur and Bevier Professor of
Engineering, University of Pittsburgh



Joe Fortunak
Professor of Chemistry,
Howard University

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We are all consumers!

- * We buy products and services; they all have impacts, they are all primed for improvement with respect to environmental footprint.



12

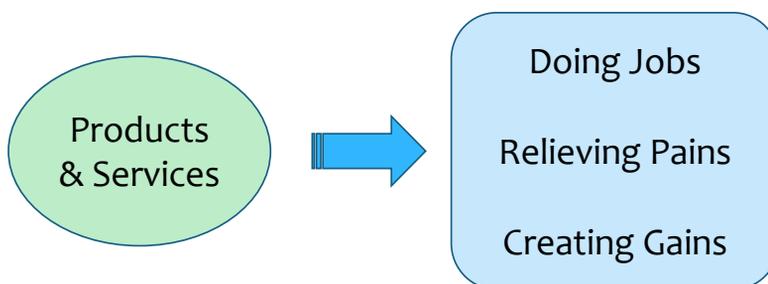
If you're at a US university in the chemical sciences (chem. & chem. Eng.), it's very hard to incorporate sustainable product design into your program

- * **Product design** (core to mechanical engineering).
- * **Life cycle impact analysis** (core to civil & environmental engineering).
- * **Project management** (core to business schools, industrial engineering).
- * Etc.

Hence, a whirlwind trip through sustainable chemical product design: merging cutting edge product design paradigms with use of sustainability metrics



13



14

Jobs: Functional, social, emotional

*What functional jobs are you helping your customer get done?
(e.g. perform or complete a specific task, solve a specific problem, ...)*

*What social jobs are you helping your customer get done?
(e.g. trying to look good, gain power or status, ...)*

*What emotional jobs are you helping your customer get done?
(e.g. esthetics, feel good, security, ...)*

*What basic needs are you helping your customer satisfy?
(e.g. communication, sex, ...)*



15

Modern Approach to Product Design: Design Thinking

“a **human centered** innovation process that emphasizes observation, collaboration, fast learning, visualization of ideas, rapid concept prototyping, and concurrent business analysis”

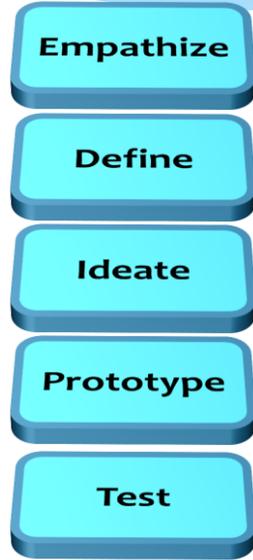


16

Design Thinking: Customer Focus

The modern approach to product and/or service design

Design Thinking



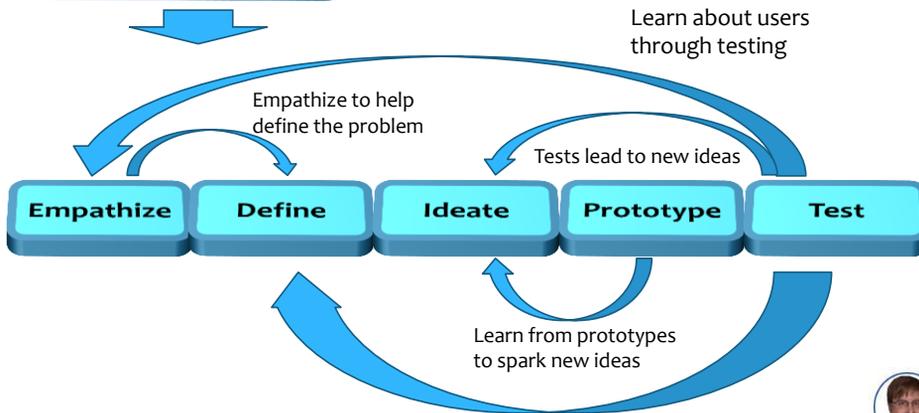
The process appears linear at first glance



17

A Nonlinear Process

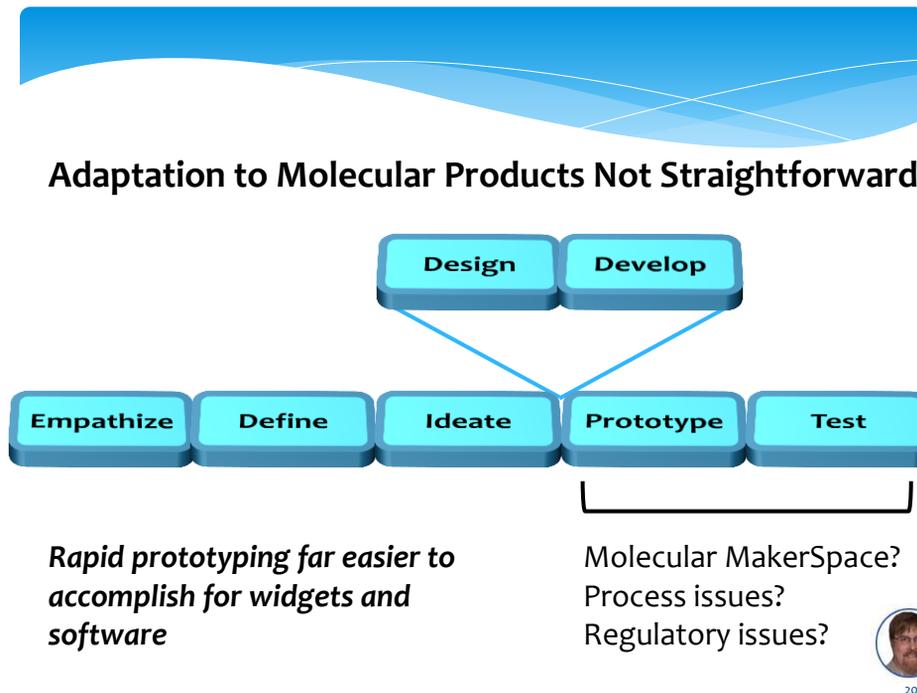
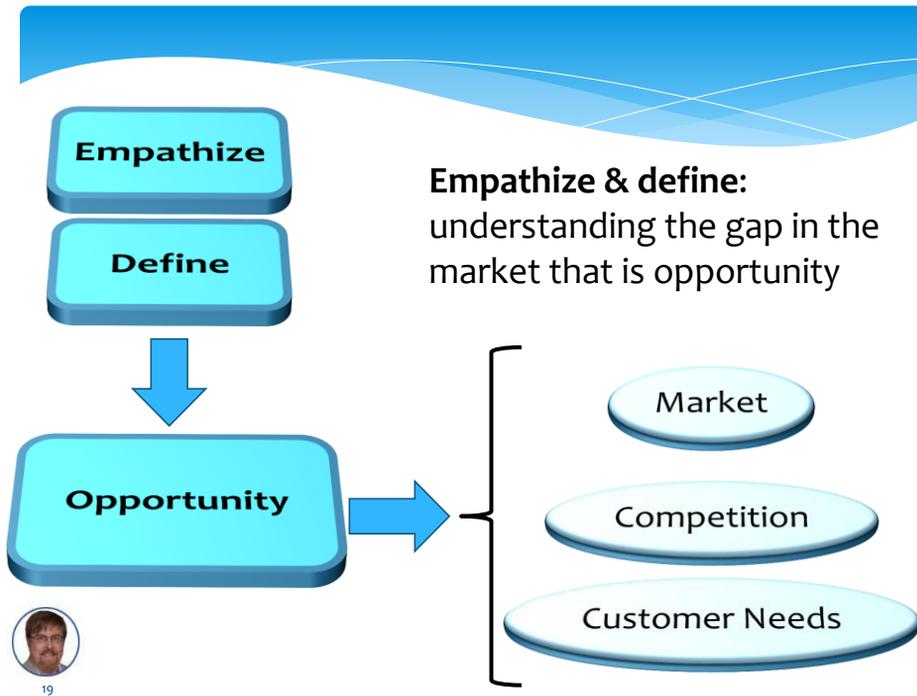
Design Thinking

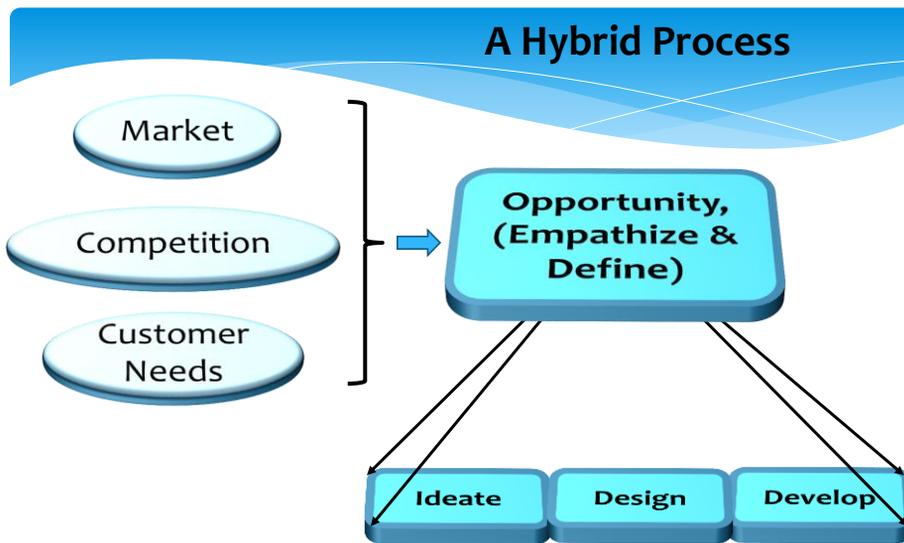


Tests reveal insights that redefine the problem



18





Still relies heavily on customer interaction



21



Understanding your customers needs and desires is a crucial part of the opportunity identification and design process



22

Desired customer outcomes?

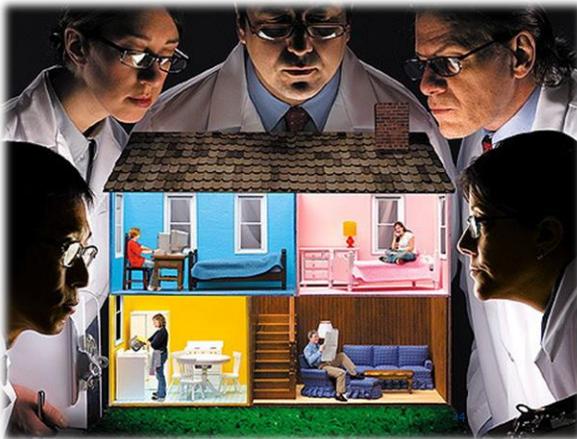
- * **Ethnography** (craft the hypothesis)
- * **Voice-of-the-customer** (try to confirm the hypothesis)
- * **Further confirmation:** Getting prototypes into customers' hands.



23

Uncovering desired outcomes: use of ethnography

Observing customers interacting with products; gaining insight not found from focus groups alone.



“If I had asked my customers, they would have wanted faster horses”

Henry Ford (well, not really...)



24

The key to **ethnography = observation** (initially) *without* hypothesis....the hypothesis comes as a result of the interaction.

Uncovering the Hidden Obvious



25

Ethnography and product design



26

Ethnography and product design



When asked about motors, sportsmen said that color and style were unimportant, but ethnographers noticed that they **tended to coordinate** their motors with their boats...and even their trucks.



27

Ethnography and product design

Further, observation suggested that the back pain suffered by fishermen was due to poor ergonomics of the foot pedal



- Customers will say one thing, but do another
- Customers may not be aware of how they are altering their behavior to accommodate designs presented to them.



28

Cognitive Bias: stuff that leads you down the wrong path

- * **Say/Do Gap:** Researchers have found that consumers were not reliable predictors of their own purchase behavior for any of the types of goods studied. Even focus groups have a high error rate and routinely fail to perform satisfactorily.



29

The Say/Do Gap, if misread, can have catastrophic consequences

- * **New Coke (April 23, 1985)**
 - * \$4 million and 200,000 consumer interviews
 - * In focus groups, consumers clearly preferred sweeter “new Coke”



30

The Say/Do Gap, if misread, can have catastrophic consequences

- * **New Coke (April 23, 1985)**
 - * \$4 million and 200,000 consumer interviews
 - * In focus groups, consumers clearly preferred sweeter “new Coke”



31

The Say/Do Gap, if misread, can have catastrophic consequences

- * **New Coke (April 23, 1985)**
 - * \$4 million and 200,000 consumer interviews
 - * In focus groups, consumers clearly preferred sweeter “new Coke”
 - * In reality, consumers felt “a bond” with old Coke; classic Coke introduced 79 days later.



32



→ Design Firm Sundberg-Ferar asked residents of a senior living community if they had problems with their walkers. **“We asked them for an hour: Is there anything you could do differently with this walker?”** he said. **“But, no, everyone loved the product.”**



33



→ Design Firm Sundberg-Ferar asked residents of a senior living community if they had problems with their walkers. **“We asked them for an hour: Is there anything you could do differently with this walker?”** he said. **“But, no, everyone loved the product.”**

→ As the group left the room and returned to the walkers, company researchers quickly noted how the customers had been working to improve the product, ***essentially unbeknownst to themselves***. “One woman has a bicycle basket tied with shoe laces to the front of the walker to carry stuff”; “Another guy had taken duct tape and fashioned a cradle for his phone”.



34

“For 18 additional cents, we added a place for their telephone, bottle of aspirin, their magazine, all those things they can’t carry,” – “And now this product has a compelling competitive advantage over other walkers.”



35

Ethnography leads to a hypothesis

- * Customer interviews
- * Customer surveys
- * Rapid prototyping and customer trials

If we understand desired customer outcomes, we can then propose novel concepts to address them.



36

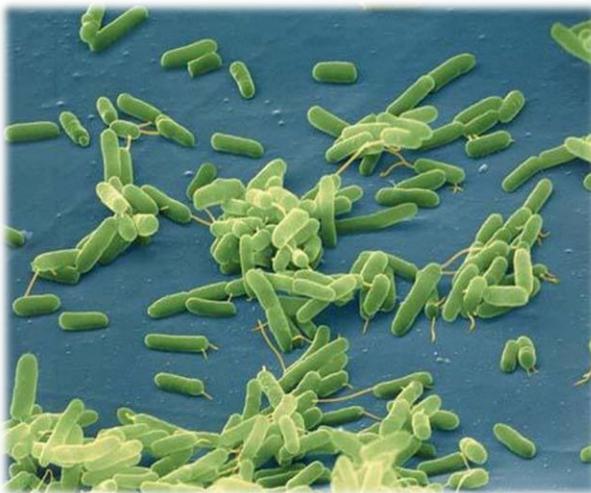
Ideation to create novel concepts

Concept vs. design?

- * Concept is a broader grouping, contains multiple possible manifestations of actual designs, *all of which* satisfy the key desired customer outcome(s).
- * Design is specific - incorporates features (which lead to specifications) + molecular structures, specific materials, costing



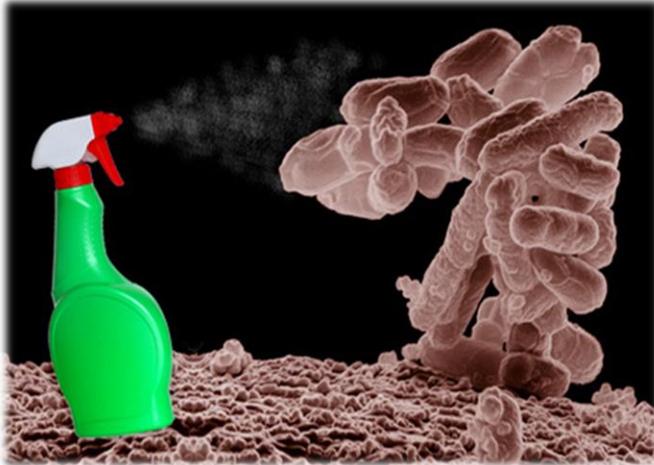
37



Customer desired outcome is *no bacteria on surfaces*



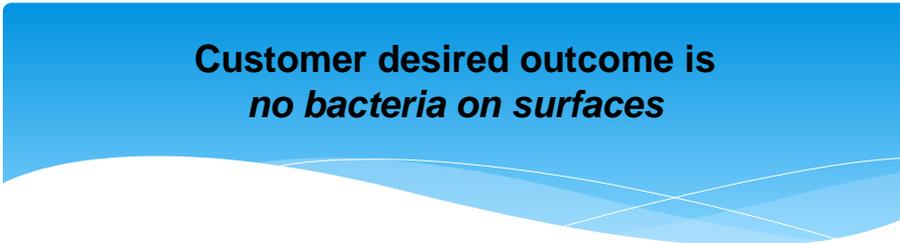
38



We could sell them a spray.....



39



Customer desired outcome is
no bacteria on surfaces

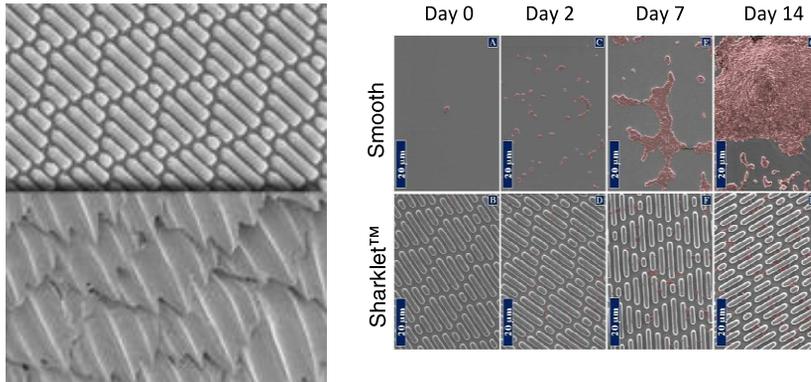


We could sell them a “greener” spray



40

Sharklet Technologies (Aurora, CO) patterned surface

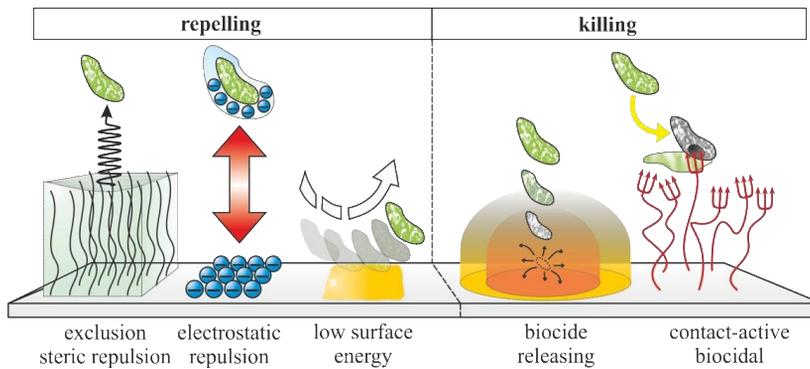


Shark skin: Very low surface frictional drag;
 B. Dean & B. Bhushan, *Phil. Trans. Roy. Soc. A* (2010); 368,
 4775-4806



41

Numerous Surface Concepts



Siedenbiedel & Teller, *Polymers* (2012)



42

Concepts can be chemical or “non-chemical”



Xenex's
“Violet”
robot in
an OR.



43

Concept versus Design

Example: Desired customer outcome = “no bacteria on surfaces”

Concept 1: = “anti-bacterial spray”

Design 1A = spray of triclosan + ethanol

Design 1B = spray of lactic acid/water

Concept 2: “Anti-bacterial surface”

Design 2A = ammonium *chloride-functional acrylic coating*

Design 2B = *Coating impregnated with silver nanoparticles*

Design 2C = *shark scale mimic (Sharklet, Aurora, CO)*

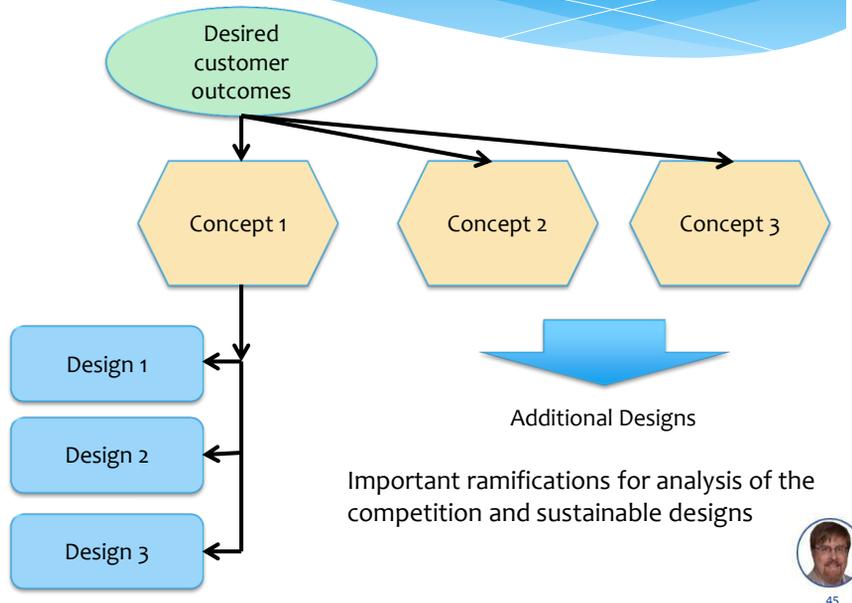
Concept 3: “Radiation”

Design 3A = UV emitting robot



44

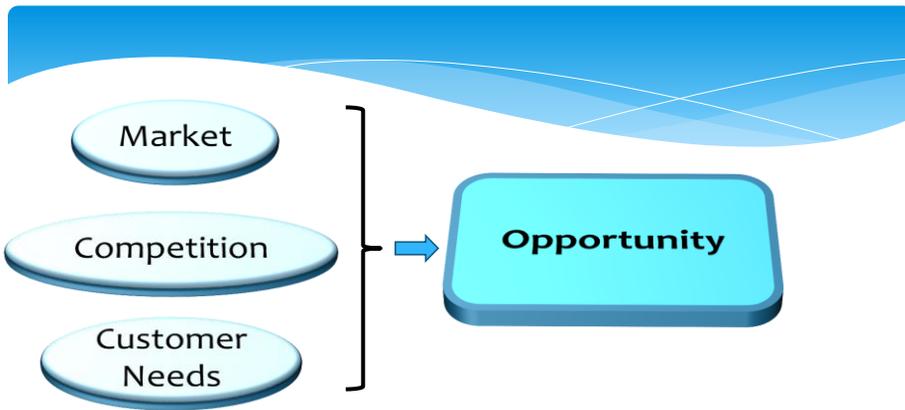
Concepts & Designs



Adding Sustainability?

- * Sustainability, environmental performance as a design constraint (as a specification)?
- * The environment as a “customer”?
- * Using sustainability as a desired customer outcome during concept ideation?
- * Use environmental problems inherent to competitive products as a means for finding opportunity?

Not all customers desire sustainability in their products,
but no customer desires hazard



- Ideally the market is significant, and growing.
- Ideally the competition is overly “relaxed”



47

A Variety of Green Opportunities



Walmart To Ban Toxic Chemicals From Some Products

By ANNE D'INNOCENZIO 09/12/13 04:30 PM ET EDT



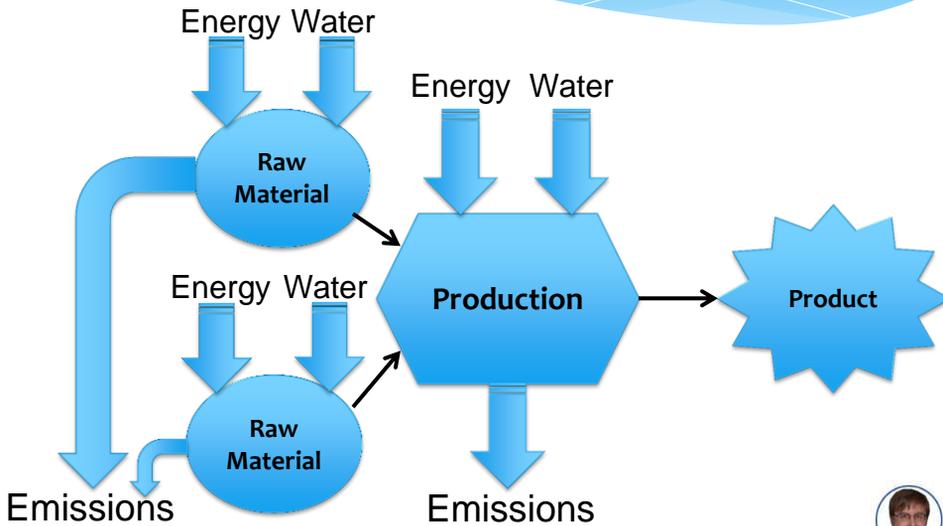
48

Life Cycle Impact Analysis



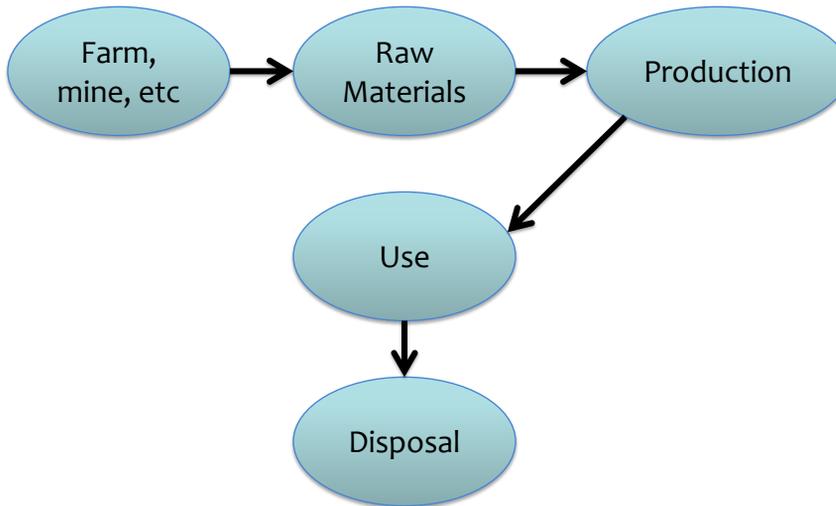
49

Life Cycle Impact Analysis: Inventory



50

LCIA: Cradle to Grave



51

TRACI: Tool for the Reduction and Assessment of Chemical and other Environmental Impacts

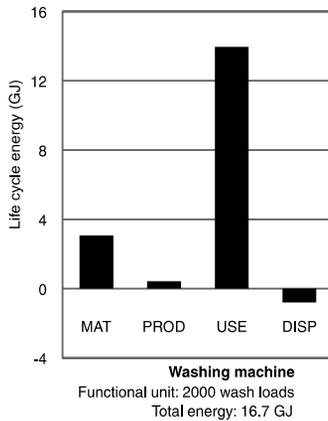
- * Ozone depletion
- * Global warming
- * Smog formation
- * Acidification
- * Eutrophication
- * Human health-cancer
- * Human health non-cancer
- * Human health criteria pollutants
- * Eco-toxicity
- * Fossil fuel depletion
- * Land use
- * Water use

See Jane Bare, et al., *J. Industr. Ecol.* 2003, 6, 49



52

Sometimes, things are as expected.



Toxics released from supplier industries that report to TRI are included through the use of the EIO-LCA. These include releases from the manufacture of replacement parts and fluids and so should encompass many of the toxic releases resulting from automotive service. The largest TRI release by weight is ammonia (9.9% of total). The industrial inorganic and organic chemicals sector generates approximately 18% of the total amount of releases, and motor vehicle parts sector generates approximately 12%.

Automotive repair produces significant quantities of waste, primarily solvent wastes, aqueous wastes, and sludges requiring disposal as hazardous waste (54). According to an EPA study (60), automotive repair produced the largest quantity (about

Cullen & Allwood, *J. Industr. Ecol.* (2009), 13(1), 27

Automobiles, from MacLean & Lave, *ES&T* (1998), 322A



53

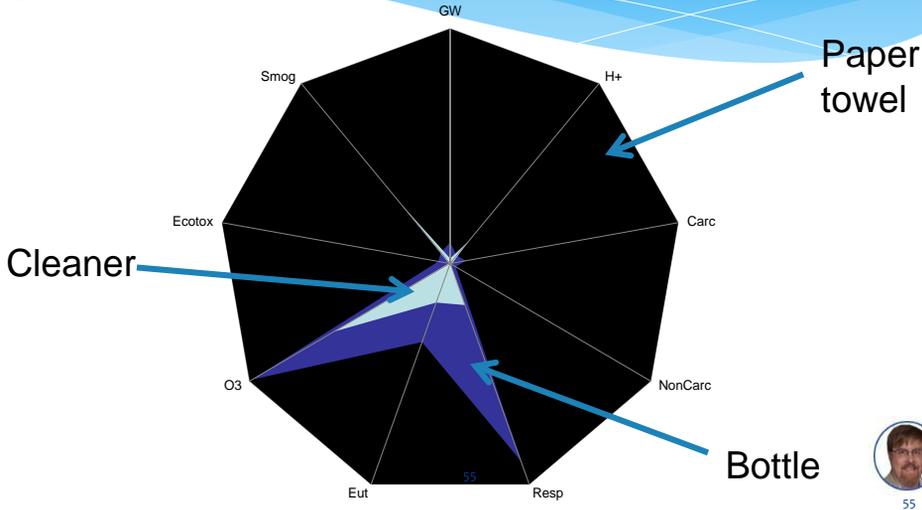
And sometimes, not so much

Traditional vs. “green” glass cleaner: the assumption is that the active ingredient will be the focus



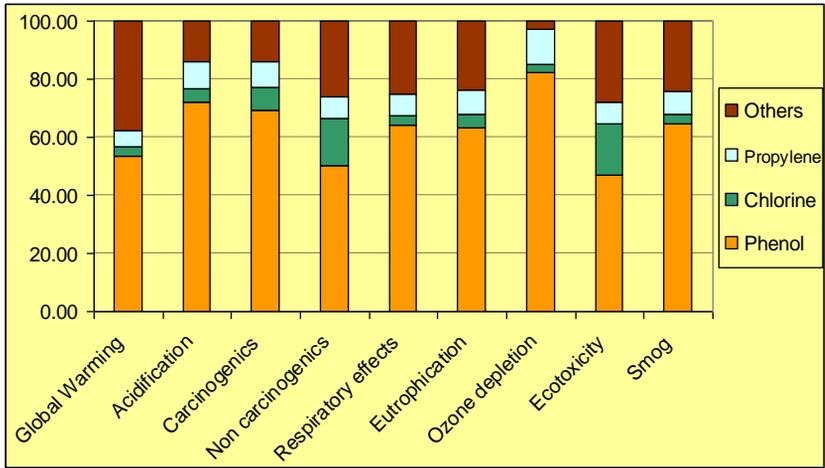
54

Fortunately, we decided to include the use of a paper towel in the life cycle analysis



Normalized Impacts of polycarbonate components

Interfacial Process



56

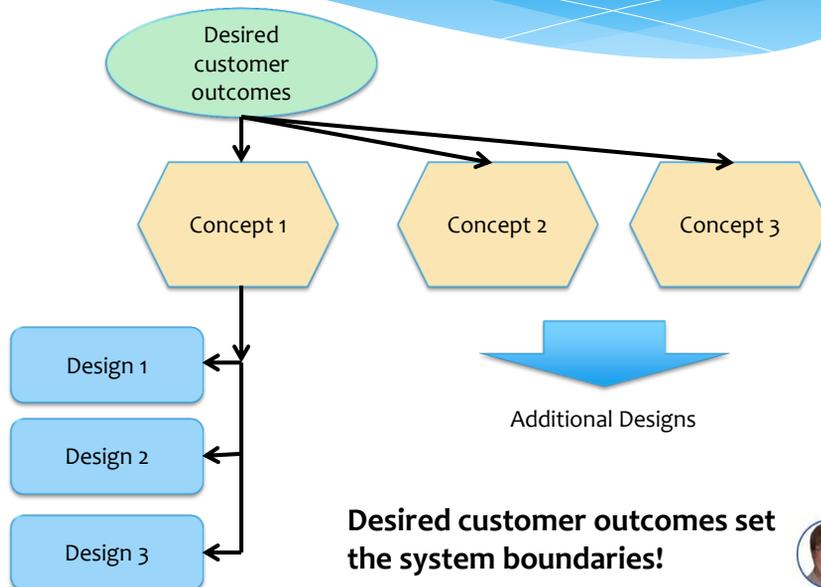
Cognitive Bias: stuff that leads you down the wrong path

- * **Projection Bias:** tendency to over-estimate the extent to which their future experience will resemble their current experience [hence the famous line from DEC Computer CEO Ken Olsen, “*there’s no reason for any individual to have a computer in his home*”].
- * **Egocentric Empathy Gap:** Decision-makers overestimate the similarity between what they value and what others value.



57

Concepts & Designs



58

Needs versus Solutions



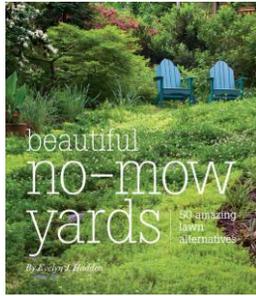
59

Needs versus Solutions



60

Needs versus Solutions



“no-mow” grass

61



61

Needs versus Solutions

We sell mowers

I want a nice looking yard



“no-mow” grass



62

Using goats to clear brush from “difficult” lots



63

Eliminate the features that aren't directly related to desired customer outcomes and also degrade environmental footprint

- * Steps in a synthesis and/or reagents
- * Middlemen
- * Parts, subsystems
- * Whole products (including via product to service)
- * Replacements (versus multi-use)

A key is to keep the desired customer outcome firmly in mind while trying to picture multiple concepts that deliver the outcomes desired – very difficult!



64

The desired outcome is “coffee without caffeine”



Coffee decaffeination using methylene chloride



65

The desired outcome is “coffee without caffeine”



Coffee decaffeination using methylene chloride

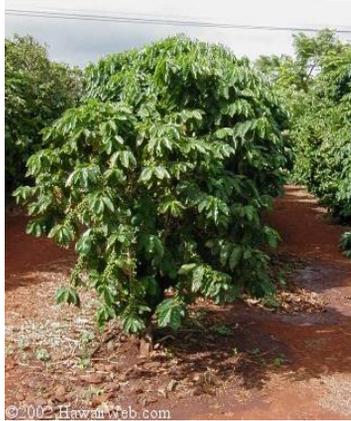


Coffee decaffeination using CO₂ (not a “solvent” by FDA)



66

The desired outcome is “coffee without caffeine”



Coffee beans without caffeine



67

The traditional touchscreen: desired outcome is interaction



68

Or, any surface can be a touchscreen

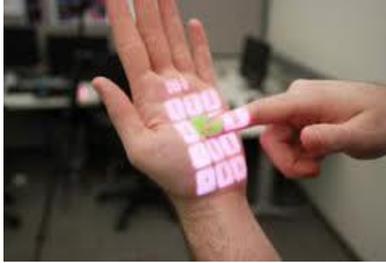


Figure 3. A short throw projector with mounted Kinect. ⁶⁹

Bio-based Ethanol



Corn as
feedstock



70

Bio-based Ethanol



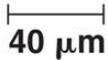
Switchgrass
or waste
cellulose



71

Employ Cyanobacteria to Generate Ethanol



Cyanobacteria  40 μm

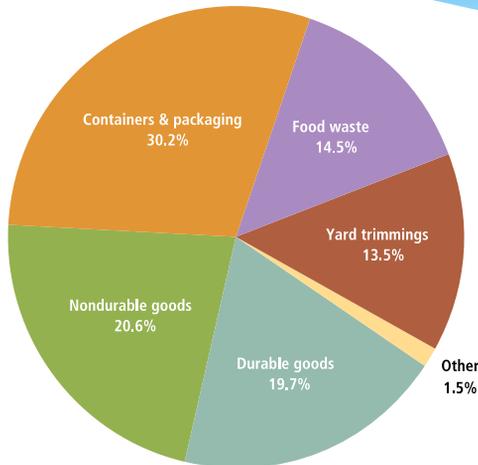
Bacteria employ
 CO_2 & sunlight as
feedstocks;

Joule Unlimited
(Bedford, MA) is in
process of plant
scale-up.



72

Packaging: Desired Outcome = "Protection until Use"



250 tons of MSW;
packaging = 75
million tons

U.S. EPA: Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2011



73

The desired customer outcome is containment + protection



Willy Wonka: The "everything is edible" room



74

Coca-Cola Bottles: The Desired Outcome is Containment + Protection

The Coke Ice Bottle



75

Variations on the Theme

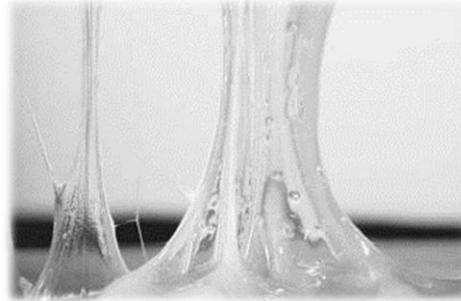


PACKAGING THE FUTURE
edible wrappers, containers and bags



76

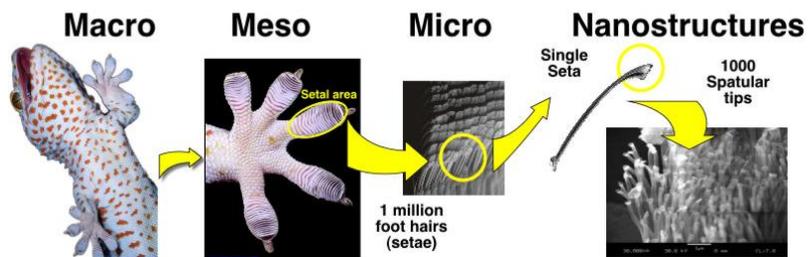
“Attachment” in the usual way... Adhesives



77

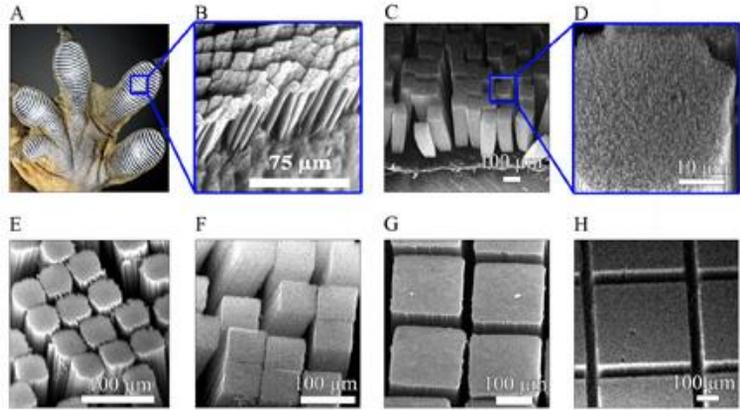
Or how the gecko does it....

Gecko adhesive system



78

Synthetic gecko mimics



79

“Out-geckoing” the gecko!

AS STICKY AS A GECKO...BUT TEN TIMES STRONGER!

Glass

Curly on top
Straight nanotubes

Dry adhesive made of carbon nanotubes

As adhesive dragged downwards, curly nanotubes on top make more contact with glass, and cling tight

Adhesive is easiest to take off pulling perpendicularly to the surface it is stuck to

NSF



80

To summarize this very fast introduction

- * Human-centered design; desired customer outcomes set the system boundaries
- * Life cycle impact analysis reveals flaws in competitive products, and hence helps to ID opportunity
- * Brainstorming to lead to new concepts, not just new designs from well-worn concepts.
- * Check your work; LCIA to verify improved e-footprint



81



Look for folks struggling with existing “solutions”

Innovation is always possible



82



How to Create Sustainable Product Design that Satisfies Production Demand and Eco-Awareness



Eric Beckman
Entrepreneur and Bevier Professor of
Engineering, University of Pittsburgh



Joe Fortunak
Professor of Chemistry,
Howard University

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How to Create Sustainable Product Design that Satisfies Production Demand and Eco-Awareness



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Joe Fortunak
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Howard University

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Bill Courtney, Washington University

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