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Evan Beach
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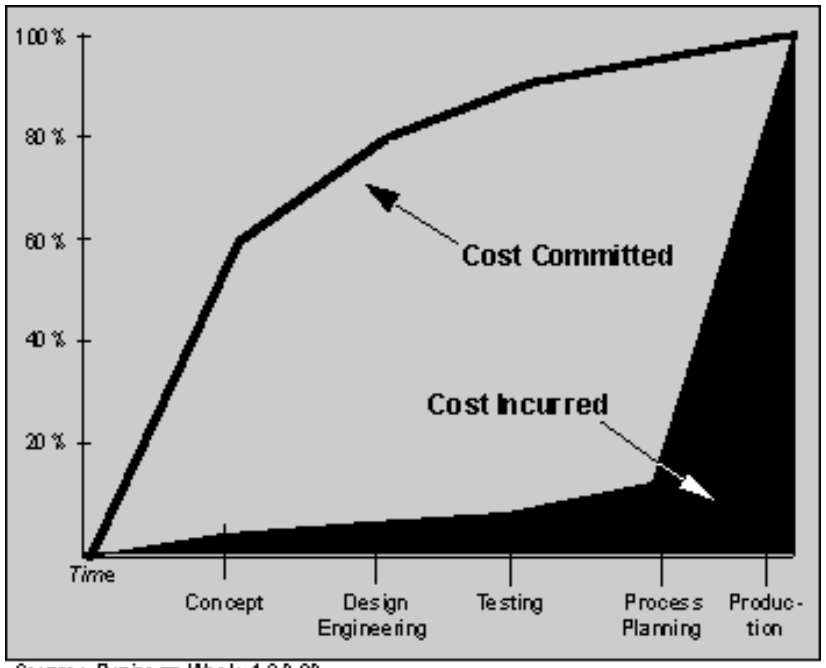
# Impacts of Design Decisions

- For a typical product, 70% of the cost of development, manufacture and use is determined in its design phase.
- Analogous for environmental impacts



Source: Business Week 4-30-90

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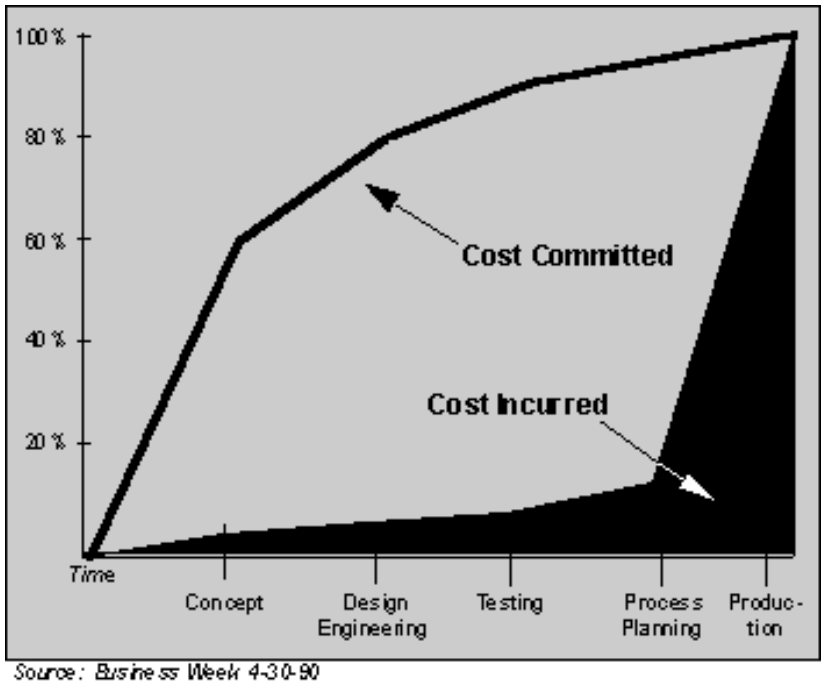
# Impacts of Design Decisions

- Engaging in upfront product design can:
  - increase efficiency
  - reduce waste of materials and energy
  - reduce costs
  - impart new performance and capabilities
  - incorporate “inherently benign”



Source: Business Week 4-30-90

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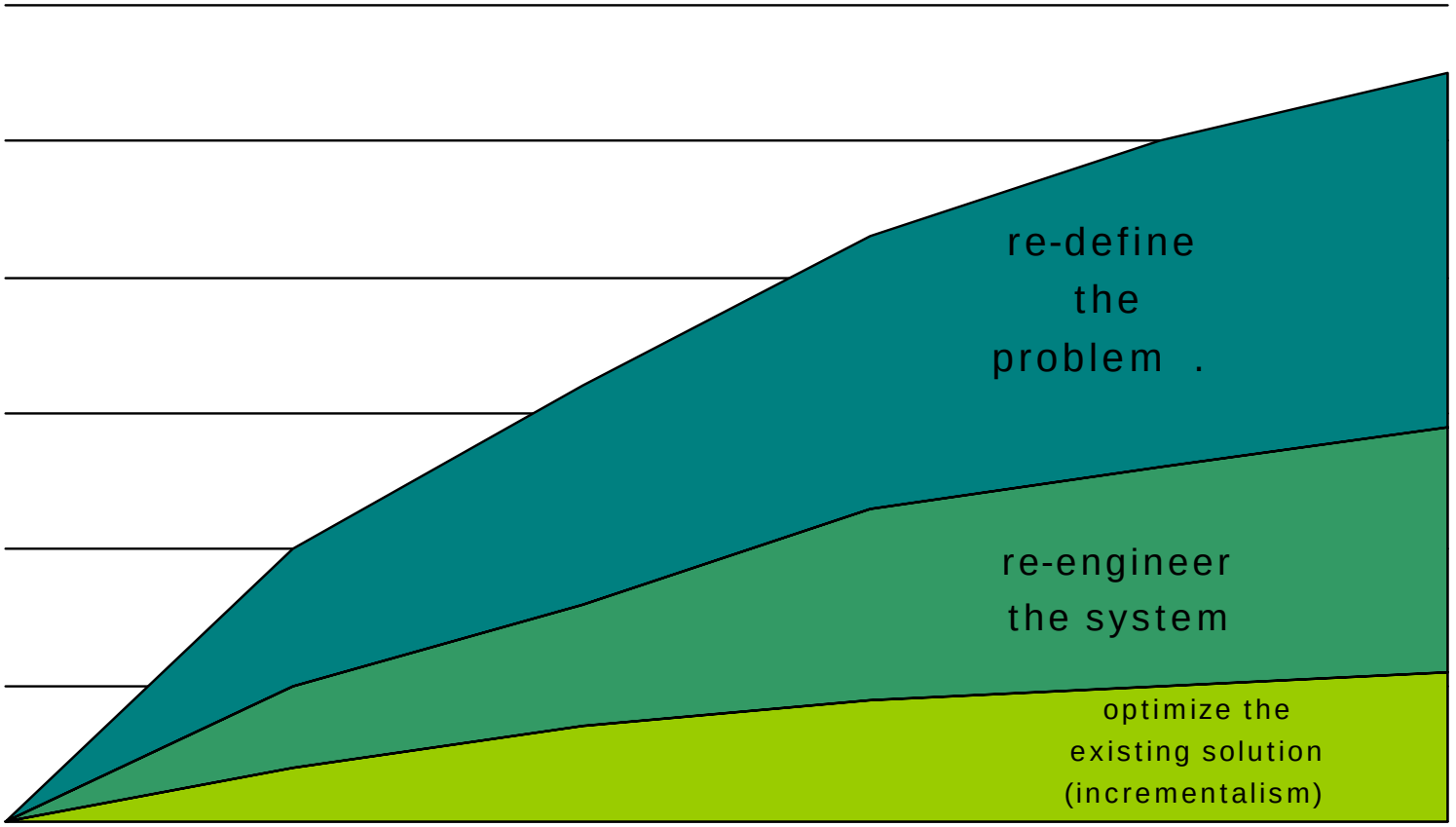
# Not just how you design but <u>what</u> you design

## Schematic of potential benefits vs. investments




investments (i.e., time, money, resources,energy)

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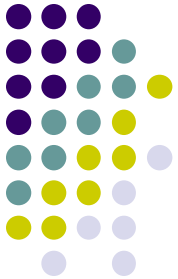
# Design criteria



"Performance" must evolve

from

function, cost, quality, safety

to include

environment, human health, social wellbeing

# Design considerations

- Inherently benign
- Resiliency
- Life cycle
- Systems thinking
- Intended lifetime

# Innovation

## Provide service without physical entity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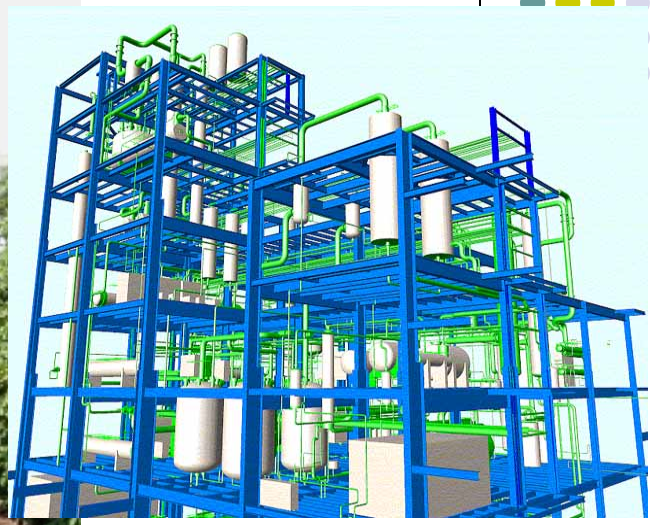
Beckman, Zimmerman, and Anastas, 2006

# Innovation, sustainability, & chemical product design

Coffee decaffeination using methylene chloride


Coffee beans without caffeine



Coffee decaffeination using $CO_2$ (not a “solvent” by FDA)

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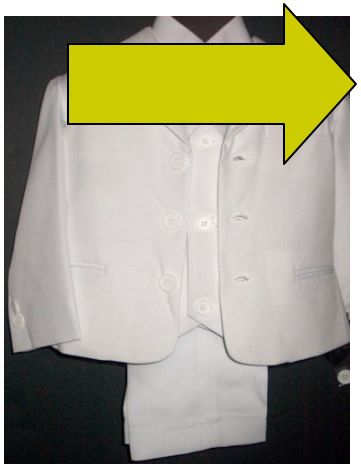
Beckman, Zimmerman, and Anastas, 2006

# Innovation, sustainability, & chemical product design

**The task is the cleaning of clothes; current product is detergent.**


Detergent



Self-cleaning clothes?


Concentrated detergent

**Entirely consistent with environmental and economic goals.**

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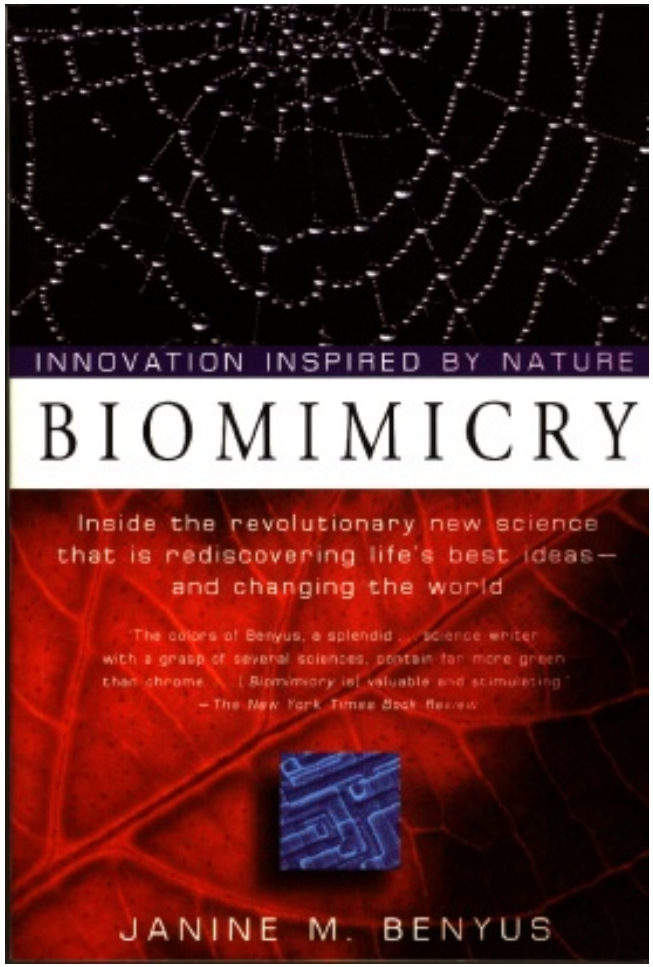
Beckman, Zimmerman, and Anastas, 2006

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Progress in Materials Science

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# Biological materials: Structure and mechanical properties

Marc André Meyers *, Po-Yu Chen, Albert Yu-Min Lin, Yasuaki Seki

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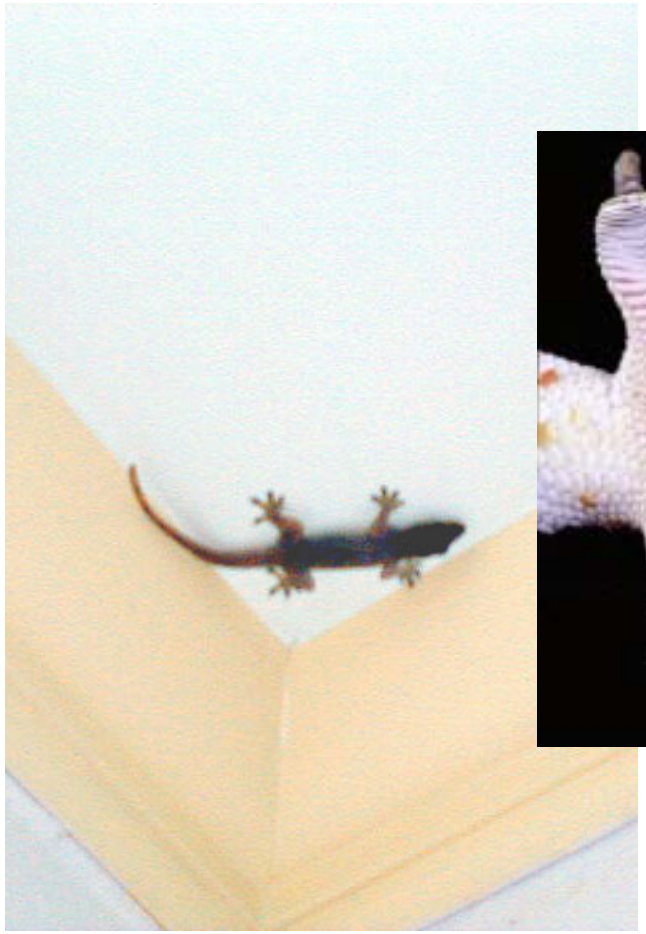
# Biomimetic Adhesives



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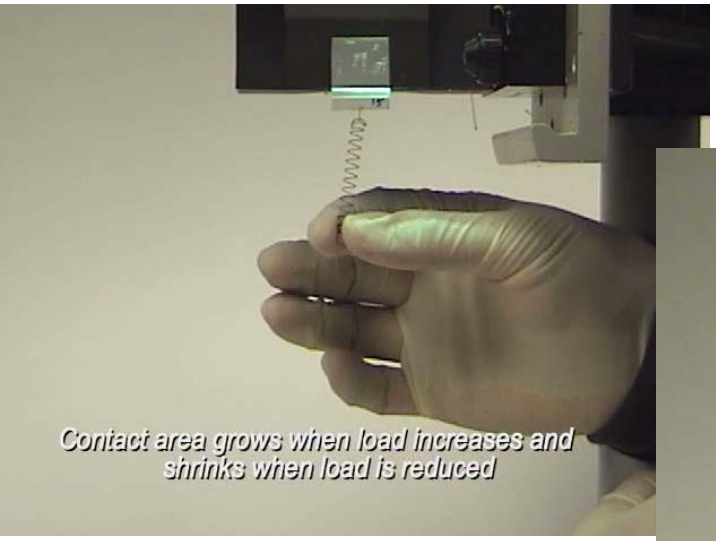
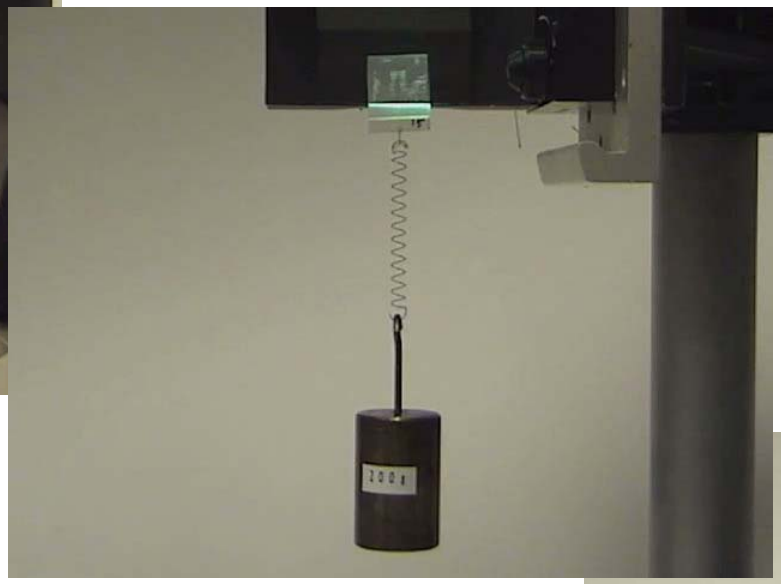
# “Gecko Tape”

R. Fearing, UC-Berkeley




http://robotics.eecs.berkeley.edu/~ronf/Gecko/interface08.html

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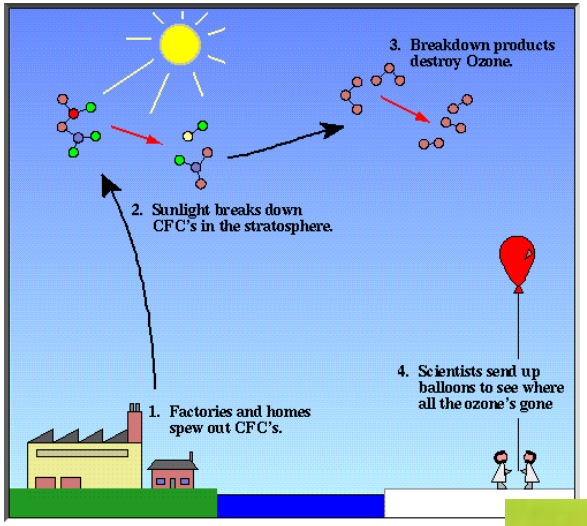
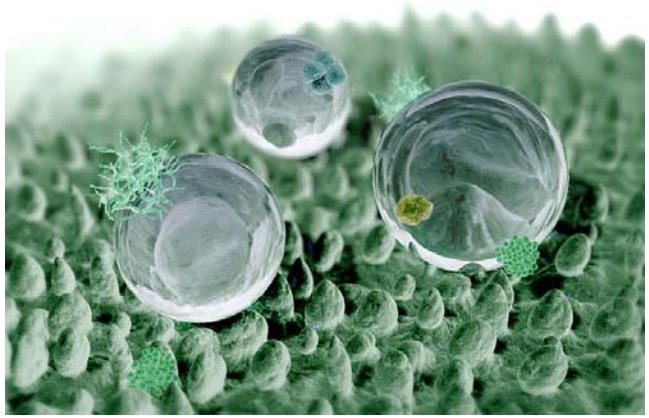
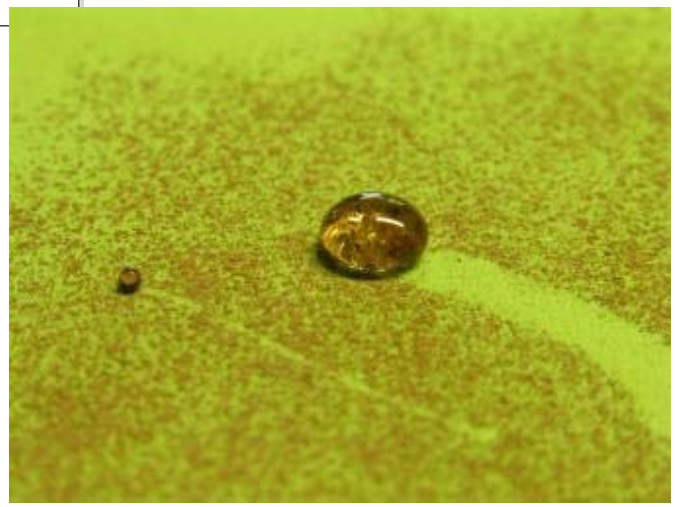
# Our own experience: cleaning fuel lines





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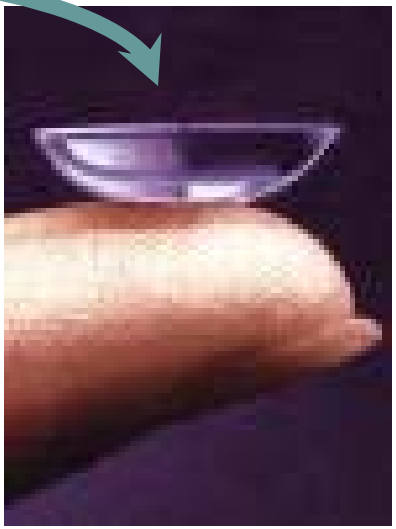
# View complexity as an investment

- Natural complexity

Chitosan, a chitin-derived polymer, is under study as a new contact lens material. Squid pen chitosan can be made into transparent, tough lenses that are gas permeable and can absorb the right amount of water for making comfortable contact lenses.

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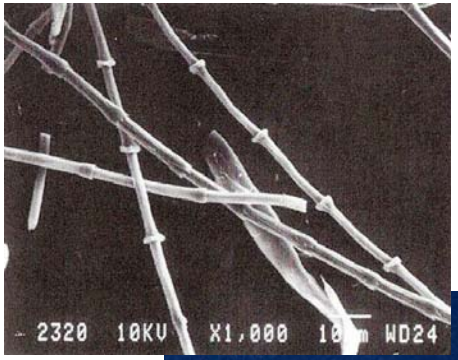
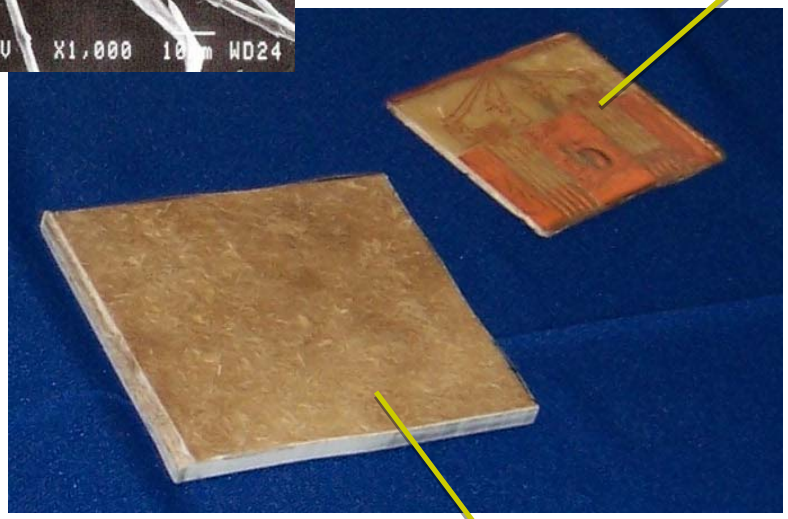
# View complexity as an investment

- Natural complexity



(R. Wool, U. of Delaware)

- Chicken feathers and plant oils are molded into a composite material that approximates the shape and feel of silicon.
- When the researchers tested it for speed, they found that the composite allowed movement at about twice the rate of silicon.
- Not to mention the chips are much lighter.

Recycled paper-chicken feather mat, comparable in strength to lumber

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# Durability rather than immortality

- Biodegradable foams - starch-based packing material which consists of food-grade inputs (starch and water)
  - can be readily dissolved in domestic/industrial water systems at the product's end of life
  - competitive with traditional polystyrene packing

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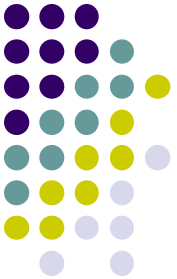
# 12 Principles of Green Engineering



**I** - Inherently non-hazardous and safe
**M** - Minimize material diversity
**P** - Prevention instead of treatment
**R** - Renewable material and energy inputs
**O** - Output-led design
**V** - Very simple
**E** - Efficient use of mass, energy, space & time
**M** - Meet the need
**E** - Easy to separate by design
**N** - Networks for exchange of local mass & energy
**T** - Test the life cycle of the design
**S** - Sustainability throughout product life cycle

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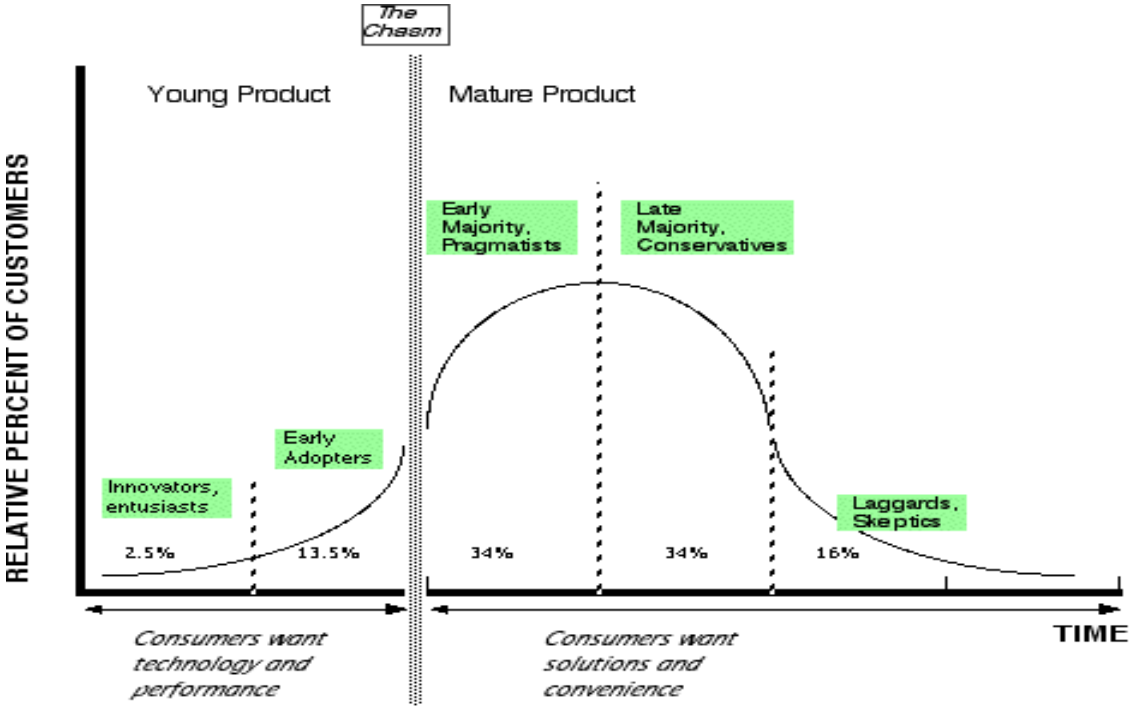
Anastas, P. T.; Zimmerman, J. B. Design through the 12 Principles of Green Engineering. *Environ. Sci. Tech.* **2003**, *37*, 95A-101A.
Mnemonic: S. Tang, R. Bourne, R. Smith and M. Poliakoff

# Green Engineering has been applied in the design of:

- Chemical process systems
- Construction material design
- Urban development
- Consumer electronic devices
- Manufacturing systems

# Innovative Science and Technology: Only part of the solution

- Technology Diffusion

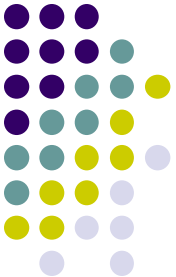



In the early days, innovators and enthusiasts drive the market. They are industry insiders, or technology managers elsewhere, so they want technology per se. But at this point, the technology just is not good enough to attract other users, it does not solve actual non-technology related needs.

In the later days, after the technology matures, the pragmatists and conservatives dominate. They want convenience and workplace solutions unrelated to technology, so the concerns of innovators (i.e., technology per se) are not influential.

*(Adapted from Moore, Rogers, Norman)*

# Innovative Science and Technology: Only part of the solution



- Technology diffusion
- Capital investment demands
- Regulatory restrictions
- Patent life concerns
- Lack of trained and knowledgeable workforce
- Displacing existing technologies
- Supply and infrastructure issues
- Underinvestment in basic R&D in “green” technologies