



**ENGINEERING SOLUTIONS FOR SUSTAINABILITY:  
MATERIALS AND RESOURCES 3**

# Toward a Circular Economy

February 18–19, 2017 | Denver, Colorado





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# **Circular Economy - *A Pathway to Resource Recovery and Recycling***

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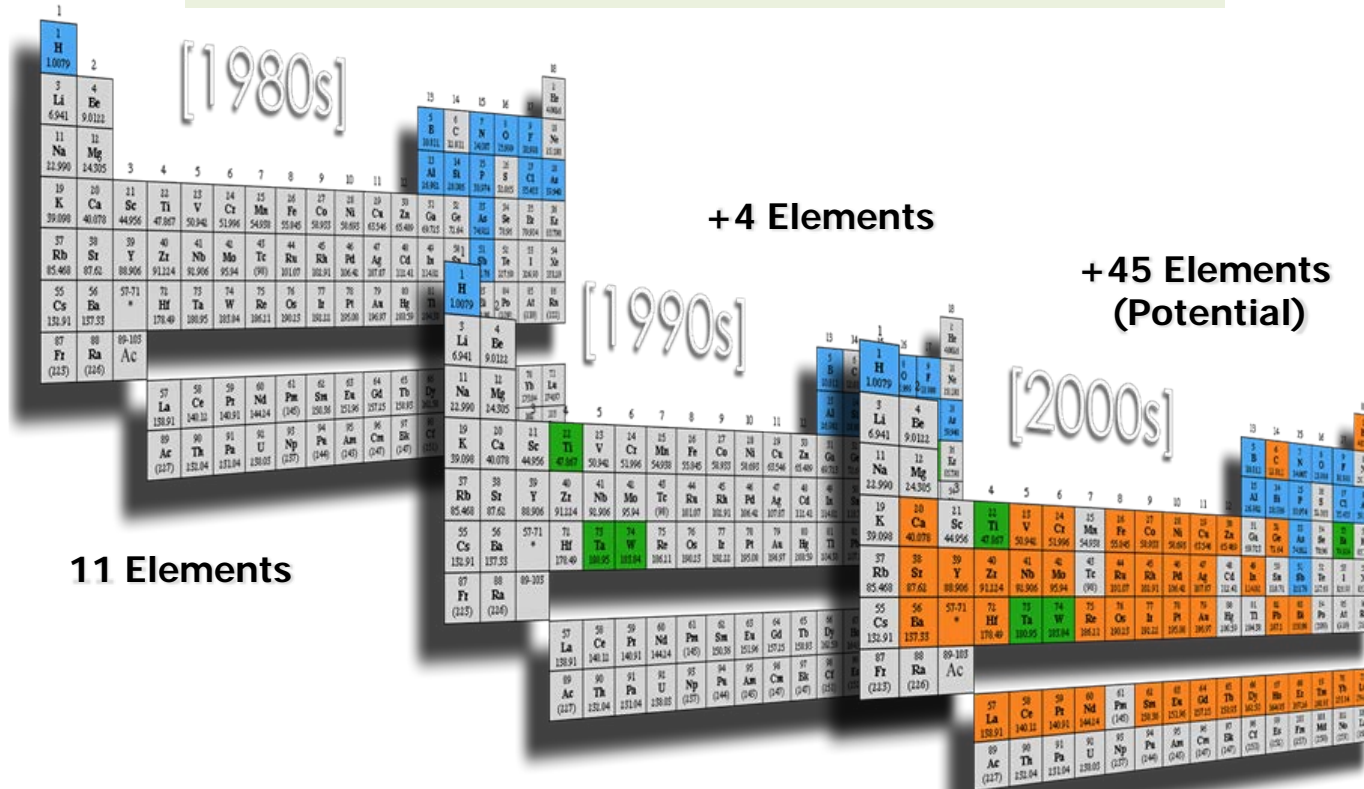
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# PREMISE

- *Who owns the ore? The material?*
- *Finite vs. Infinite*
- *Waste? ... a Resource?*
- *Repair, Recover, Reuse, Reduce*
- *Manufacture for disassembly, recover, and recycle*

# Computer Chip Elemental Contents



Source: T. McManus, Intel Corp., 2006

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# Bronze Age

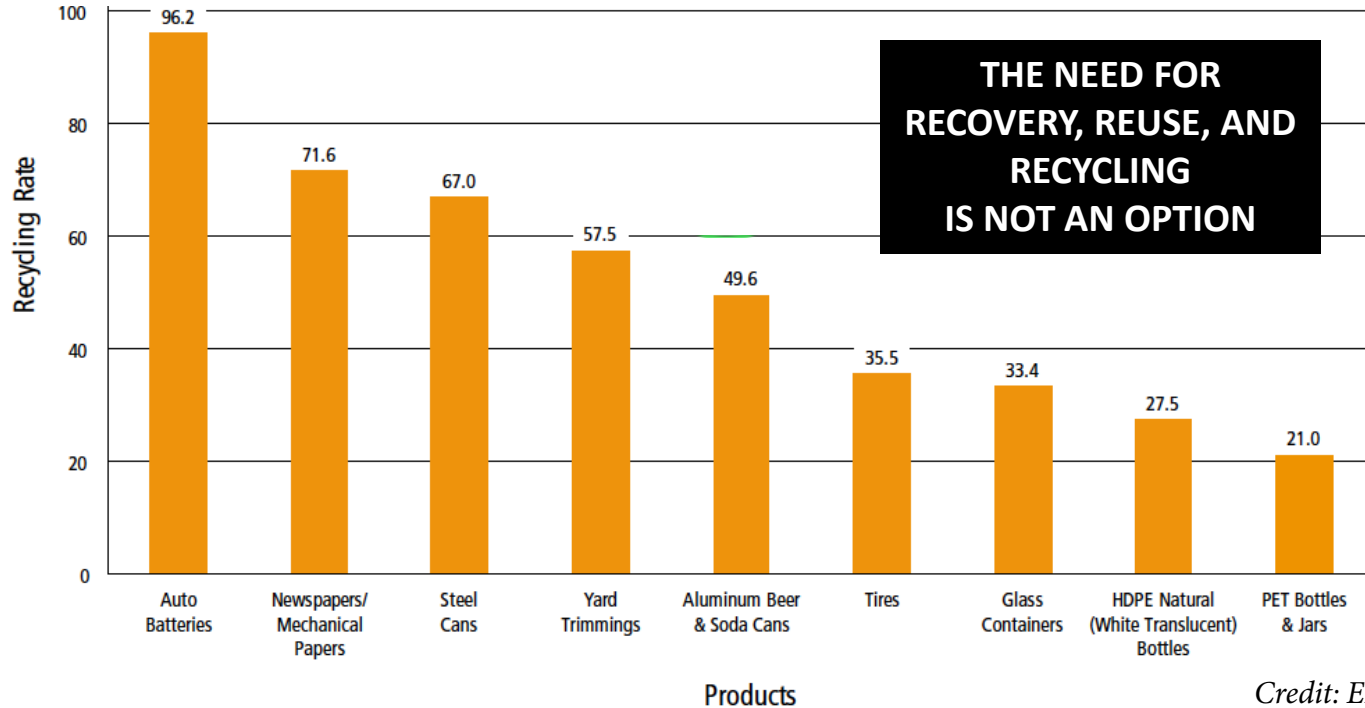
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## Iron Age

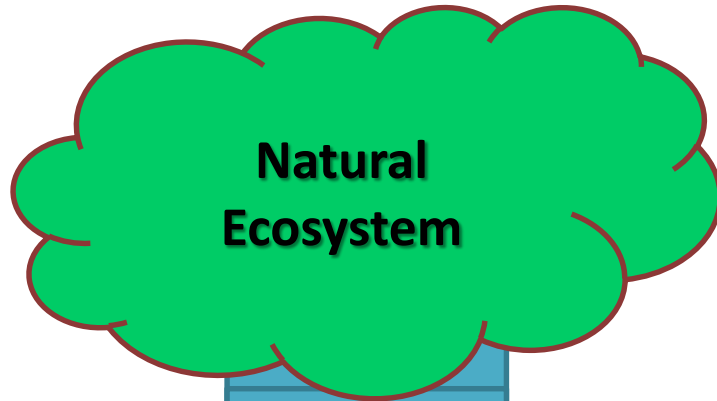
## Everything Age



# 2010 Recycling Rates in the U.S.



# A Lesson from Nature



## Natural Ecosystem

### EQUILIBRIUM

#### Uses a Few Elements

(mostly C, N, O, H)

#### Is Cyclic

Materials circulate and transform continuously

#### Subsystems

Have evolved & use waste as a resource

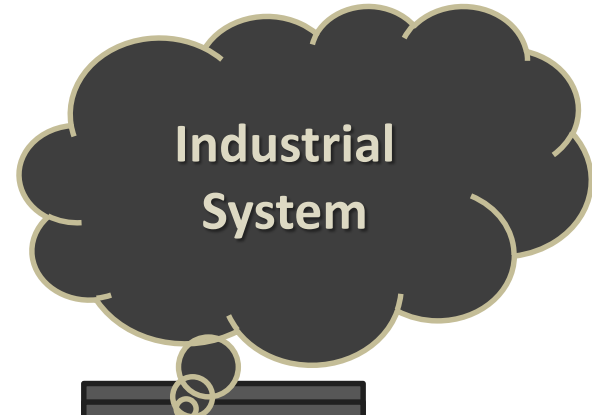
#### Closed Loop

*No waste.*

Each subsystem provides sustenance for others

### INDICATOR OF WELL-BEING

**WHAT WE NEED IS A  
CRADLE TO CRADLE  
APPROACH**



## Industrial System

### GROWTH

#### Uses most of the Periodic Table

#### Is Linear

Transforms materials into products & waste

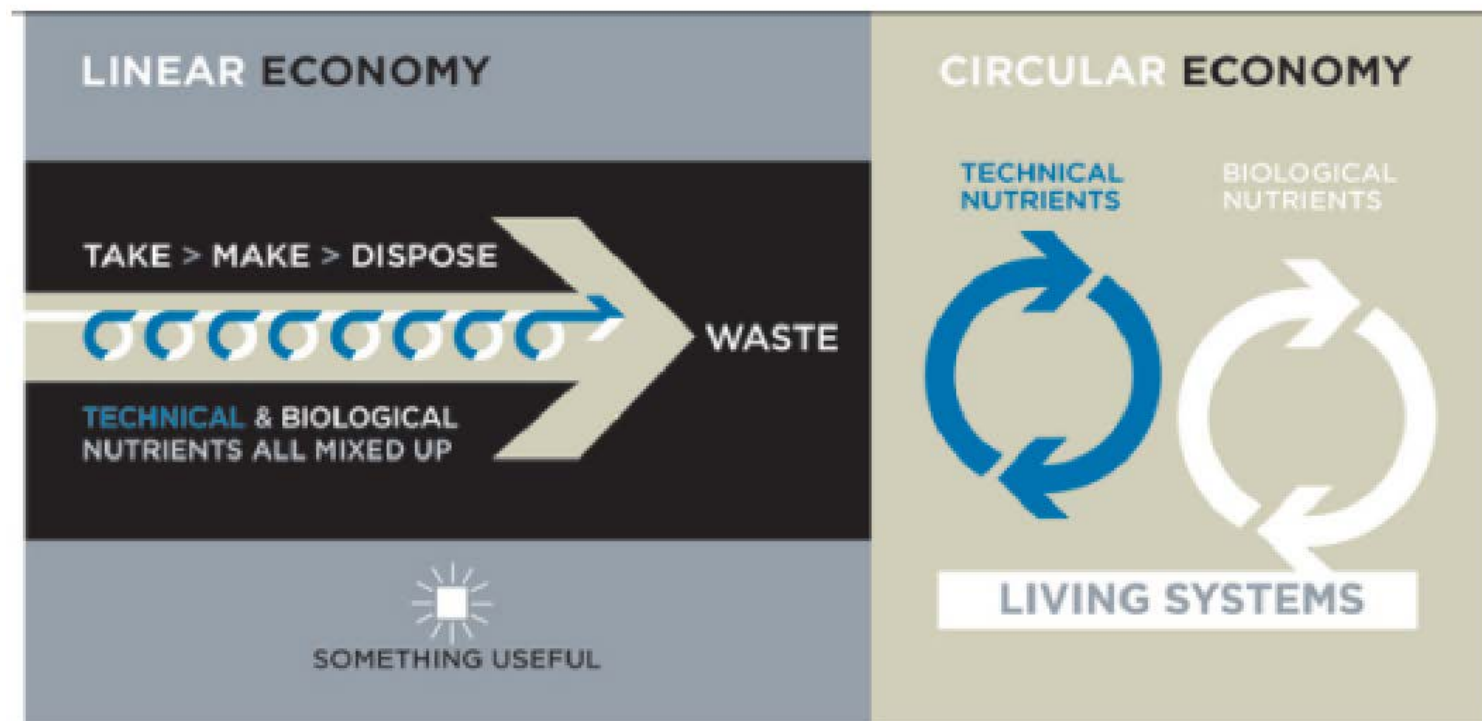
#### Lack of Subsystems

∴ Can't use waste as a resource

#### Open Loop

*Waste.*

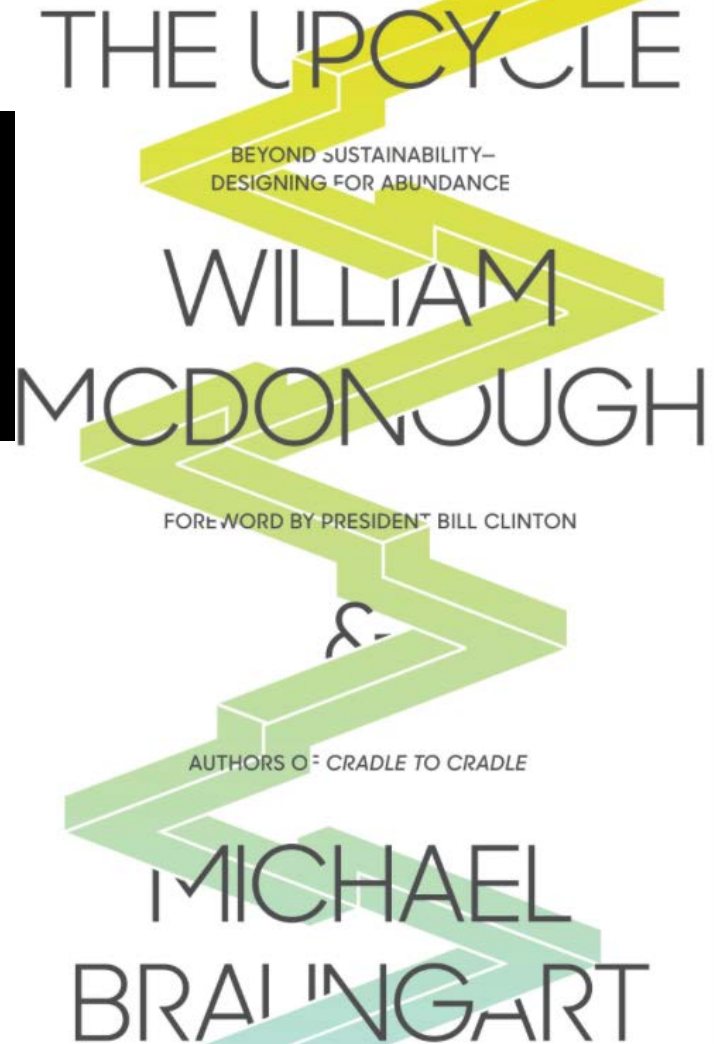
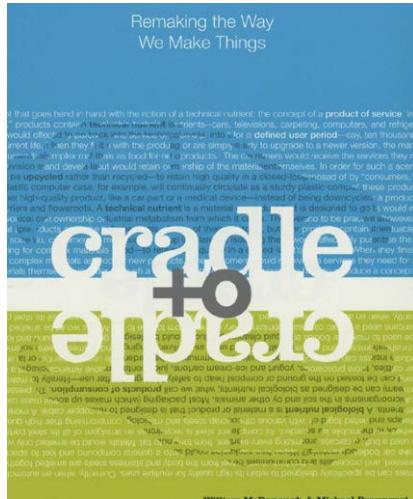
Destructive of sources which it depends



AFTER W. McDONOUGH AND M. BRAUNGART



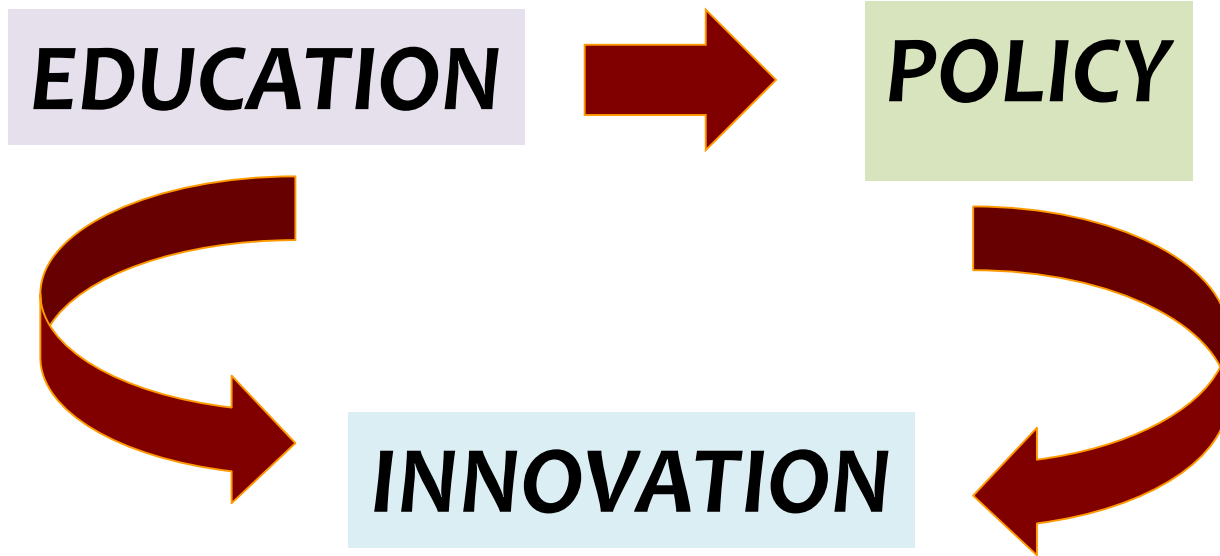
- **UPGRADE SCRAP**
- **MAKE WASTE A PRODUCT**
- **REUSE**



# Ideal Recycling Process: Aluminum Integrated Mini-mill (AIM)



# ***THREE KEY AXES***



MANUFACTURE  
for DISASSEMBLY

*HAVING **END of LIFE** IN MIND  
at the ONSET of the  
MANUFACTURING PROCESS*

## CIRCULAR PRODUCT DESIGN AND PRODUCTION

- Material choice optimized for recovery
- Design to last
- Modularisation/Standardization
- Mfg for disassembly

orative by design



## NEW BUSINESS MODELS

- Performance Contracts
- Products become services

## NEEDS FOR REGENERATIVE SYSTEM

- Collection system- user friendly and Cost effective
- Extraction technology optimized for volume and quality

Source: Ellen MacArthur Foundation Circular Economy team



# ***POLICY ENABLERS for a CIRCULAR ECONOMY***

## **1. Cross sector collaboration**

*(joint product development)*

- IT enabled transparency
- joint collection systems
- industry standards
- aligned incentives
- match-maker mechanisms

## **2. Favorable investment climate**

## **3. Policies to attain scale**

*Regulations in*

- Accounting
- Taxation
- Custom tariffs
- Certification
- Standardization

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