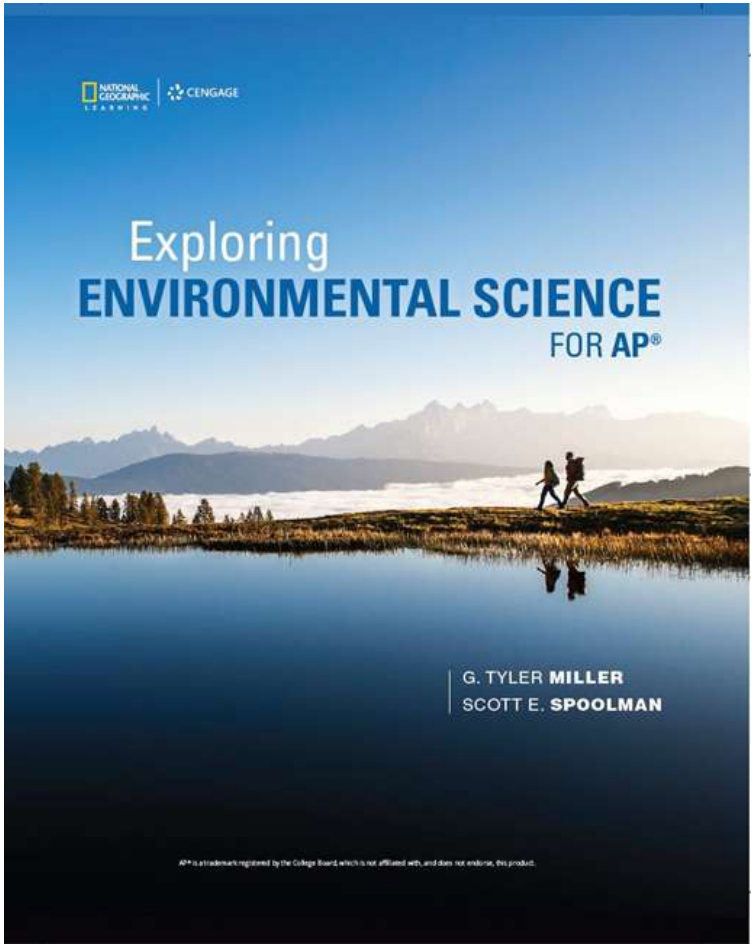
Exploring Environmental Science for AP®

1st Edition

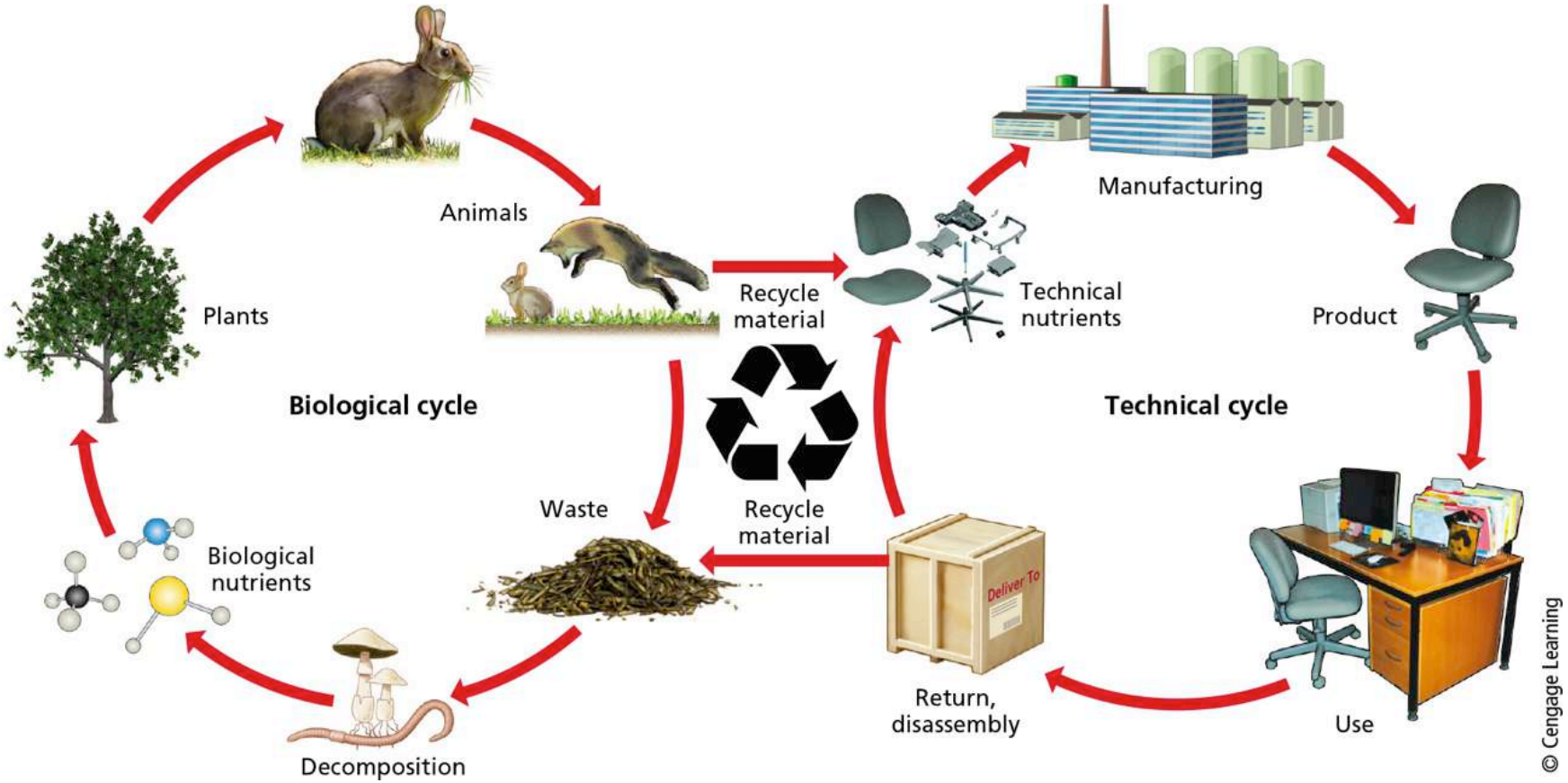


Chapter 18
Solid and Hazardous Waste

Core Case Study: Cradle-to-Cradle Design (1 of 2)

- Traditional product life cycle
  - Beginning (cradle) through disposal (grave)
- New approach: cradle-to-cradle design
  - Reusing parts over and over in other products
  - Thinking of solid wastes and pollution as potentially valuable materials and chemicals

Core Case Study: Cradle-to-Cradle Design (2 of 2)



18.1 What Environmental Problems are Related to Solid and Hazardous Wastes?

- Solid waste contributes to pollution and includes valuable resources that could be reused or recycled
- Hazardous waste contributes to pollution, natural capital degradation, health problems, and premature deaths

Solid Waste Is Piling Up (1 of 3)

- Virtually no waste in the natural world
- Solid waste
  - Industrial solid waste
    - Mines, farms, and industries
  - Municipal solid waste (MSW)
    - Garbage or trash
- Much waste ends up in rivers, lakes, the ocean, and natural landscapes

Solid Waste Is Piling Up (2 of 3)

- Single-use plastic bags
  - 100 billion used in the U.S. each year
  - Take 400–1,000 years to break down
    - Never disintegrate completely
  - Block drains and sewage systems and kill wildlife
- Discarded plastic threatens wildlife

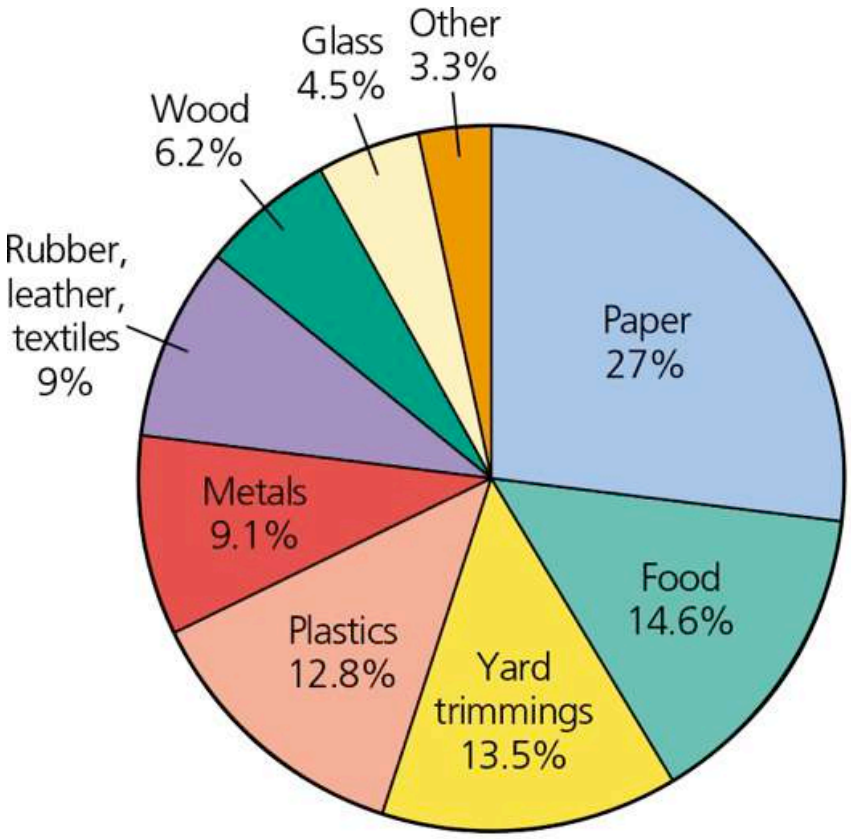
Solid Waste Is Piling Up (3 of 3)

- Where does MSW end up?
  - Buried in landfills or burned in more-developed countries
  - Open dumps in less-developed countries

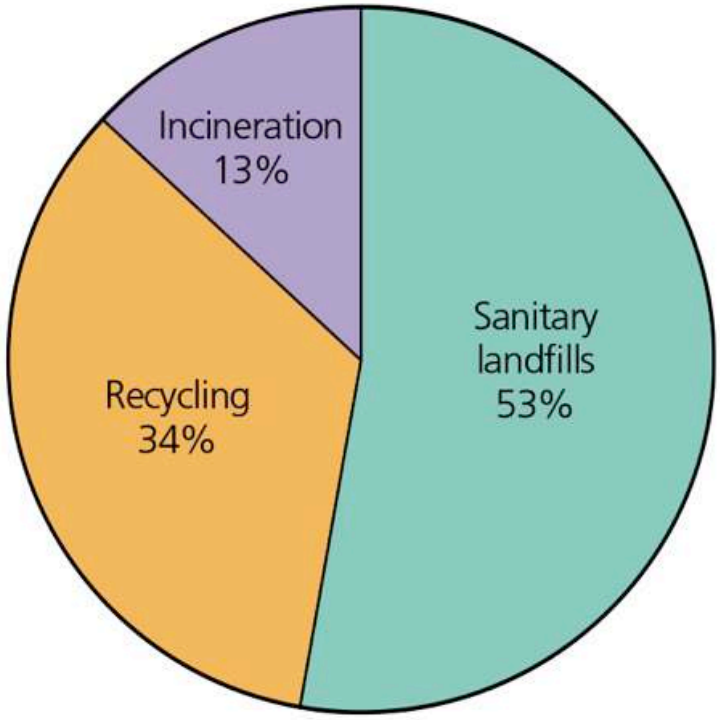
Case Study: Solid Waste in the United States (1 of 2)

- The United States is the world's largest producer of solid waste
  - And highest in solid waste per person
- Industrial waste represents 98.5% of all solid waste
  - Mining, agriculture, and industry
- Most wastes break down very slowly
  - Lead, mercury, glass, Styrofoam, and most plastic bottles do not break down completely

Case Study: Solid Waste in the United States (2 of 2)



Composition of U.S. Municipal Solid Waste



Where U.S. MSW Goes After Collection

Hazardous Waste Is a Serious and Growing Problem (1 of 3)

- Hazardous (toxic) waste
  - Threatens human health or the environment
  - Toxic, corrosive, flammable, can undergo violent or explosive chemical reactions, or can cause disease
- Classes of hazardous waste
  - Organic compounds
  - Toxic heavy metals
  - Radioactive waste

Hazardous Waste Is a Serious and Growing Problem (2 of 3)

What Harmful Chemicals Are in Your Home?

Cleanning

Disinfectants
Drain, toilet, and window cleaners Spot removers
Septic tank cleaners

Paint Products

Paints, stains, varnishes, and lacquers
Paint thinners, solvents, and strippers
Wood preservatives
Artist paints and inks

General

Dry-cell batteries (mercury and cadmium)
Glues and cements

Gardening

Pesticides Weed killers
Ant and rodent killers
Flea powders

Hazardous Waste Is a Serious and Growing Problem (3 of 3)

Automotive

Gasoline

Used motor oil

Antifreeze

Battery acid Brake and transmission fluid

Case Study: E-Waste—An Exploding Hazardous Waste Problem

- Electronic waste
  - Fastest-growing solid waste problem in the United States and the world
    - Driven by increasing sales and short life cycles
  - Leading producers: the United States and China
  - Recycling increased to 30% in 2010
    - Also shipped to other countries for processing
    - Workers (children) exposed to toxic heavy metals and chemicals
  - Contains valuable materials that could be recycled or reused

18.2 How Should We Deal with Solid Waste?

- Sustainable approach to solid waste
  - Produce less of it
  - Reuse or recycle it
  - Safely dispose of what is left

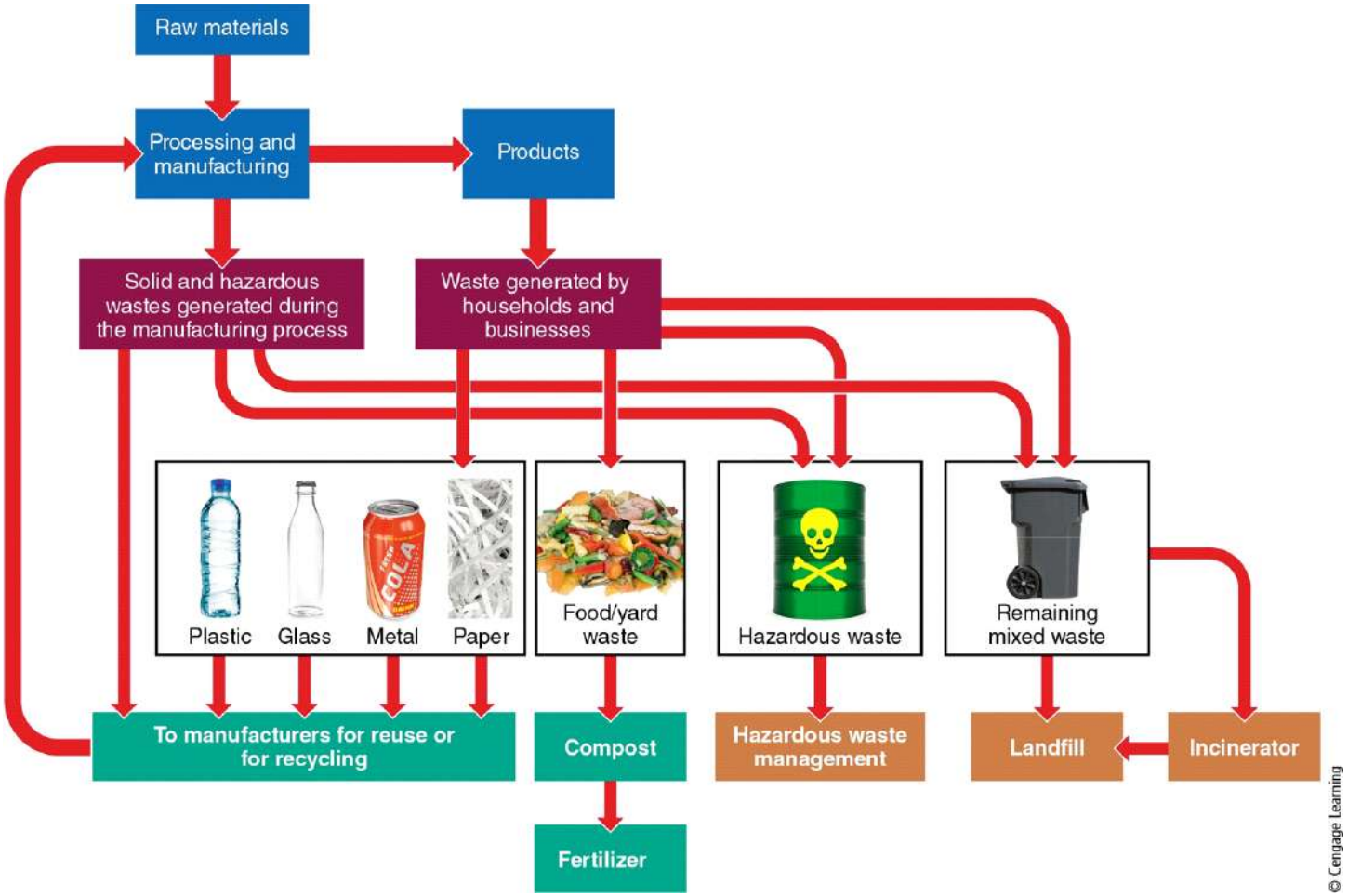
Waste Management (1 of 3)

- First produce less, then reuse or recycle, finally safely dispose what is left

Waste Management (2 of 3)

- Waste management
  - focuses on controlling waste in order to limit their environmental harm but does not attempt to reduce amount of waste
- Waste reduction
  - Reducing less solid waste and reusing and recycling
- Integrated waste management
  - Variety of strategies for management and reduction of waste

Waste Management (3 of 3)



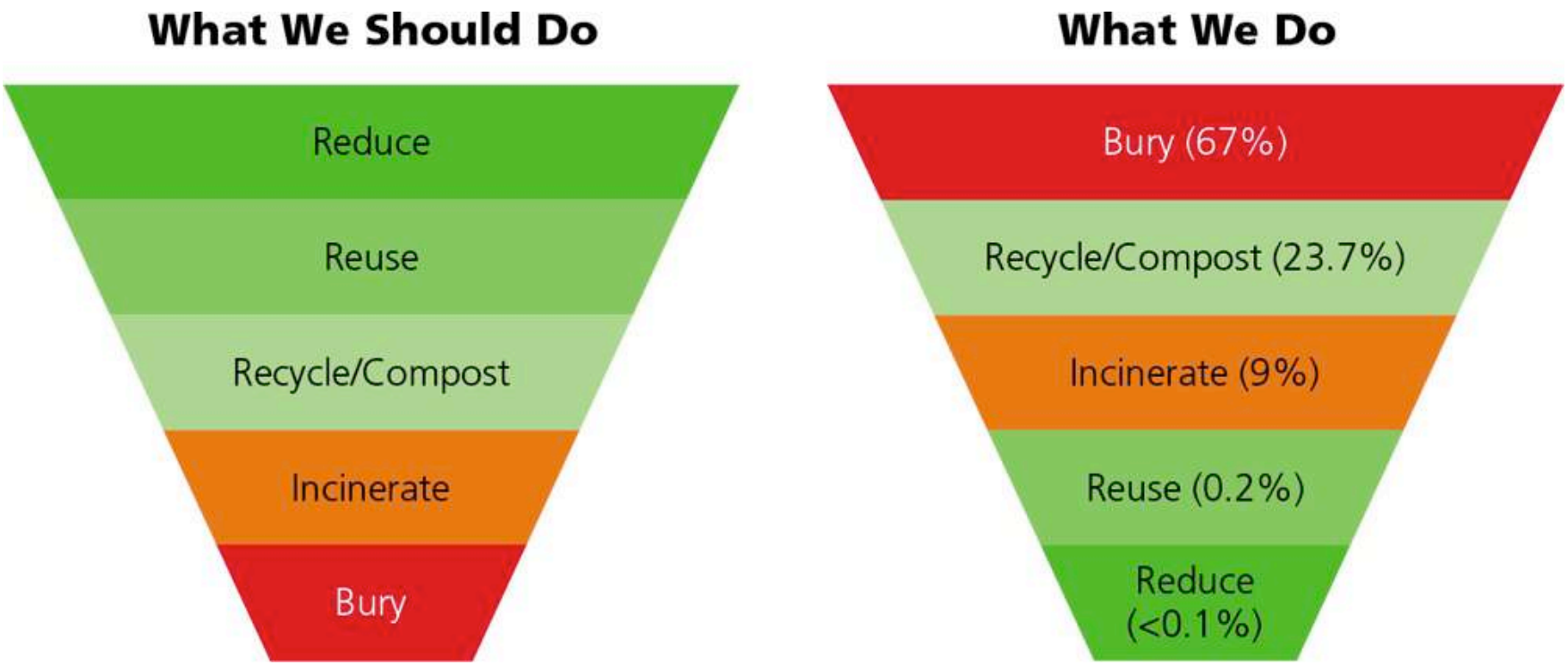
The Four Rs of Waste Reduction (1 of 3)

- Refuse–don't use it
- Reduce–use less of it
- Reuse–use it over and over
- Recycle
  - Convert used resources to useful items and buy products made from recycled materials
  - Composting
    - Using bacteria to decompose biodegradable waste

The Four Rs of Waste Reduction (2 of 3)

- Six strategies
  - Change industrial processes to eliminate or reduce use of harmful chemicals
  - Redesign manufacturing process to use less material and energy
  - Develop easy-to-recycle products
  - Establish cradle-to-cradle responsibility
  - Eliminate unnecessary packaging
  - Use fee-per-bag waste collection systems

The Four Rs of Waste Reduction (3 of 3)



18.3 Why Are Refusing, Reducing, Reusing, and Recycling So Important?

- Benefits of refusing, reducing, reusing, and recycling
  - Decreases consumption of matter and energy resources
  - Reduces pollution and natural capital degradation
  - Saves money

Alternatives to the Throwaway Economy (1 of 2)

- Today's industrialized societies have substituted throwaway items for reusable ones
- Questions to ask to reduce consumption
  - Do I really need this?
  - How many of these do I really need?
  - Is this something I can use more than once?
  - Can I repurpose this product when I am done with it?

Alternatives to the Throwaway Economy (2 of 2)

What Can You Do?

Solid Waste

- Follow the four Rs of resource use: Refuse, Reduce, Reuse, Recycle
- Ask yourself whether you really need what you're buying and refuse packaging wherever possible
- Rent, borrow, or barter goods and services when you can, buy secondhand, and donate or sell unused items
- Buy things that are reusable, recyclable, or compostable, and be sure to reuse, recycle, and compost them
- Buy products with little or no packaging and recycle any packaging as much as possible
- Avoid disposables such as paper and plastic bags, plates, cups, and utensils, disposable diapers, and disposable razors whenever reusable versions are available
- Cook with whole, fresh foods, avoid heavily packaged processed foods, and buy products in bulk whenever possible
- Discontinue junk mail as much as possible and read online newspapers and magazines and e-books

Revisiting Cradle-to-Cradle Design: Reuse Is on the Rise (1 of 3)

- European Union (EU) has banned e-waste from landfills and incinerators
  - Manufacturers required to take back products at end of their useful lives
- Finland banned all beverage containers that cannot be reused
- Rechargeable batteries
- Reusable cloth bags for groceries
  - Taxing plastic shopping bags

Revisiting Cradle-to-Cradle Design: Reuse Is on the Rise (2 of 3)

- Many cities have banned plastic bags and polystyrene foam food containers
- Shared use
  - Neighborhood tool libraries
  - Toy libraries
  - Companies rent tools and household goods

Revisiting Cradle-to-Cradle Design: Reuse Is on the Rise (3 of 3)

What Can You Do?

Reuse

- Buy beverages in refillable glass containers
- Use reusable lunch containers
- Use a reusable coffee container and carry it with you
- Store refrigerated food in reusable containers
- Use rechargeable batteries and recycle them when their useful life is over
- When eating out, bring your own reusable container for leftovers
- Carry groceries and other items in a reusable basket or cloth bag
- Buy used furniture, cars, and other items, whenever possible

Recycling (1 of 3)

- Primary, closed-loop recycling
  - Materials recycled into same type
- Secondary recycling
  - Materials converted to other products
- Types of wastes that can be recycled
  - Preconsumer, internal waste generated in manufacturing process
  - Postconsumer, external waste generated by product use

Recycling (2 of 3)

- Upcycling
  - Recycled form more useful than original item
- Downcycling
  - Recycled form less useful than original item
- Necessary steps
  - Collecting materials
  - Converting to new products
  - Buying and selling products that contain recycled material

Recycling (3 of 3)

- With incentives, the United States could recycle and compost 80% of its MSW
- 2014: e-waste contained more than one-tenth of all gold mined that year
  - Source of iron, copper, silver, and aluminum
- Composting
  - Mimics nature's recycling of nutrients

We Can Mix or Separate Household Solid Wastes for Recycling

- Materials-recovery facilities (MRFs)
  - Can encourage increased trash production
- Mixed waste approach becoming less sustainable in many communities
  - People throw trash in recycling bins
- Source separation costs less to implement
- Pay-as-you-throw or fee-per-bag
  - Charge for garbage but not recycling

Recycling Paper

- 55% of the world's industrial tree harvest used to make paper
  - Could make tree-free paper from straw, kenaf
- Pulp and paper industry
  - Energy use–world's fifth largest consumer
  - Water use
  - Pollution

Recycling Paper

- Recycled paper compared with making paper from wood pulp
  - Generates 35% less water pollution
  - Generates 74% less air pollution

Recycling Plastics

- Plastics
  - Composed of resins created from oil and natural gas
- Currently only 7% by weight is recycled in the United States
  - Many types of plastic resins
  - Difficult to separate
- 2014: First recyclable thermoset plastic

Recycling Has Advantages and Disadvantages (1 of 2)

- Advantages
  - Net economic, health, and environmental benefits
- Disadvantages
  - Costly
- Single-pickup system
- Sorting recyclables by type

Recycling Has Advantages and Disadvantages (2 of 2)

Trade-Offs

Recycling

- **Advantages**
  - Reduces energy and mineral use and air and water pollution
  - Reduces greenhouse gas emissions
  - Reduces solid waste

- **Disadvantages**
  - Can cost more than burying in areas with ample landfill space
  - Reduces profits for landfill and incinerator owners
  - Inconvenient for some

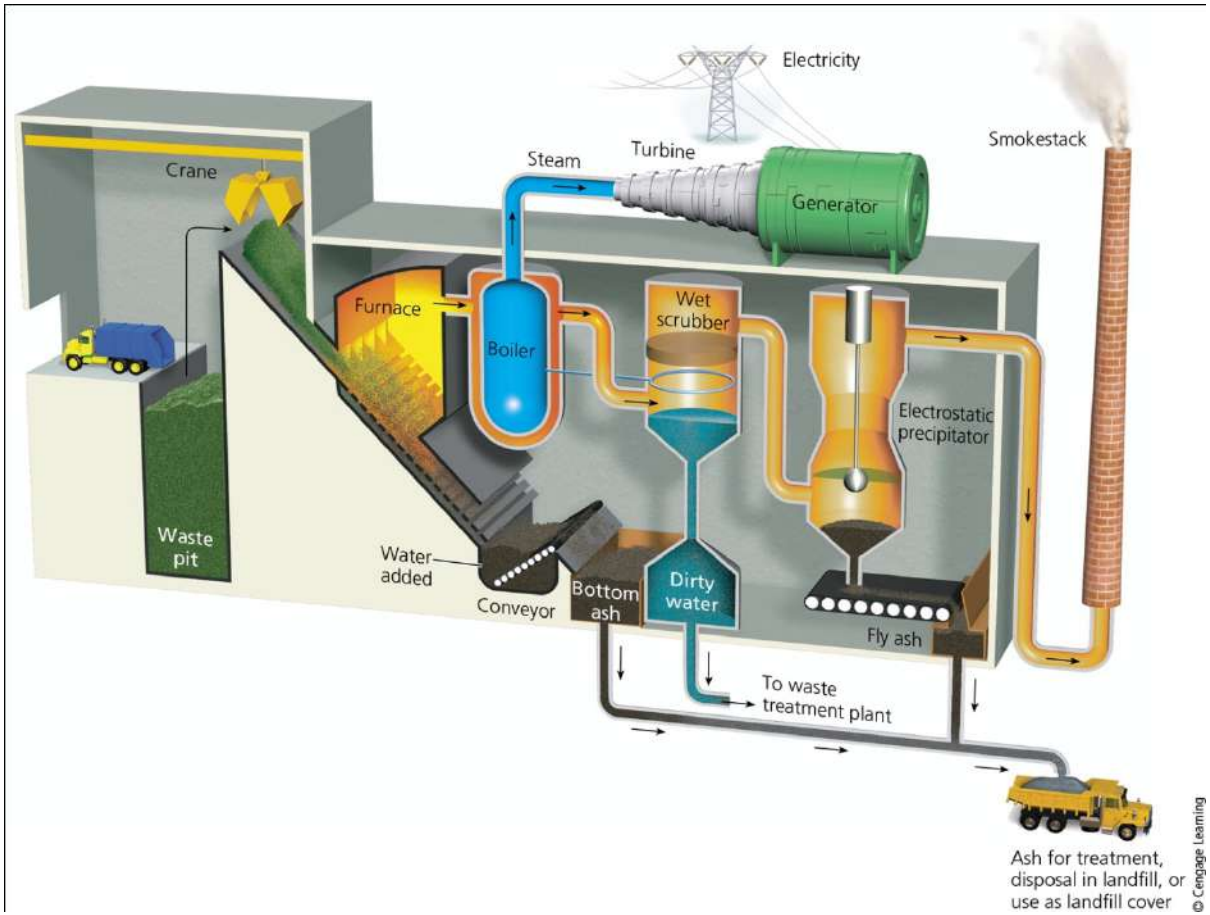
18.4 What Are the Advantages and Disadvantages of Burning or Burying Solid Waste?

- Technologies for burning and burying solid wastes well developed
  - Burning can contribute to air and water pollution and greenhouse gas emissions
  - Buried wastes can contribute to water pollution

Burning Solid Waste Has Advantages and Disadvantages (1 of 3)

- Heat released by burning trash can be used to heat water or interior spaces
  - Waste-to-energy incinerators produce electricity
- Landfills emit more air pollutants than modern waste-to-energy incinerators
- Incinerator ash contains toxic chemicals that must be disposed of or stored

Burning Solid Waste Has Advantages and Disadvantages (2 of 3)



Burning Solid Waste Has Advantages and Disadvantages (3 of 3)

Trade-Offs

Waste-to-Energy Incineration

- **Advantages**
  - Reduces trash volume
  - Produces energy
  - Concentrates hazardous substances into ash for burial
  - Sale of energy reduces cost

- **Disadvantages**
  - Expensive to build
  - Produces a hazardous waste
  - Emits some CO2 and other air pollutants
  - Encourages waste production

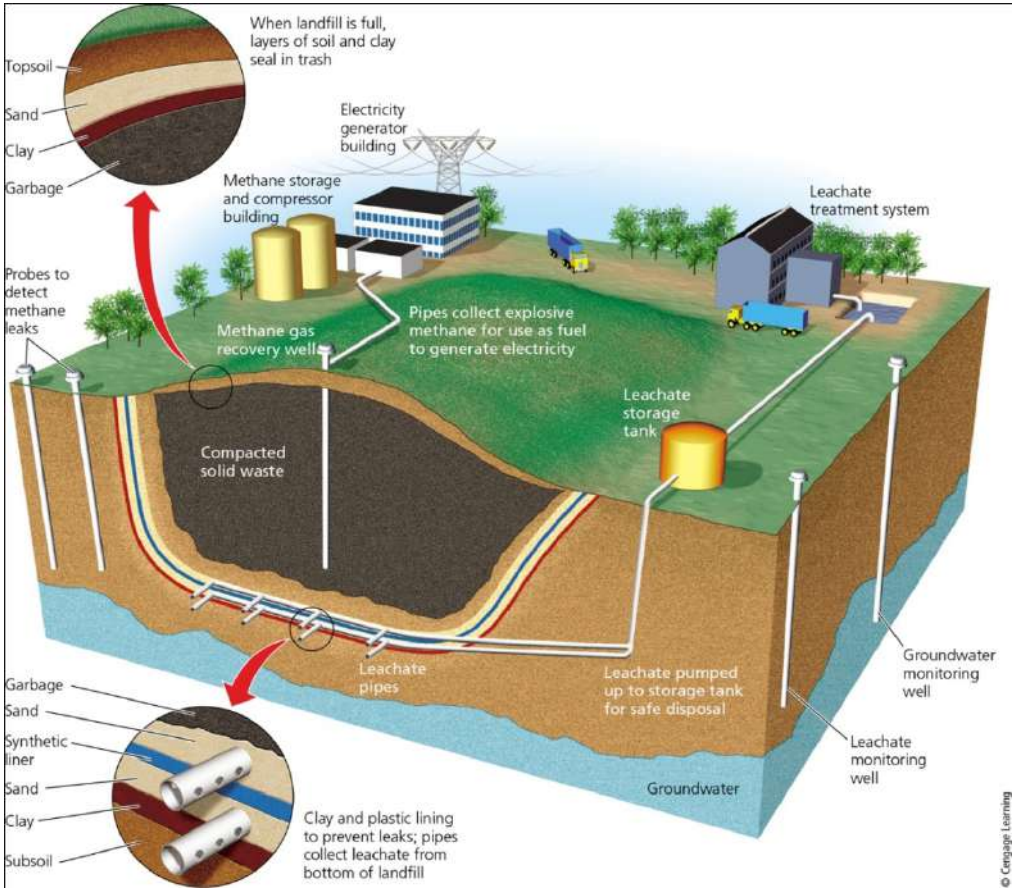
Critical Concept: Environmental Justice

- Environmental justice is the ideal that all people are entitled
- Many polluting factories, hazardous waste sites, incinerators and landfills are located in communities populated by minority groups
- Analysts argue that the ethical principle of environmental justice should carry as much weight in siting hazardous sites as economic factors

Burying Solid Waste Has Advantages and Disadvantages (1 of 5)

- Sanitary landfills
  - Compacted layers of waste between clay or foam
  - Bottom liners and containment systems collect leaching liquids
  - Some have methods for collecting methane
- Types of waste placed into landfills
  - Paper, yard waste, plastics, metals, wood, glass, and food waste

Burying Solid Waste Has Advantages and Disadvantages (2 of 5)



Burying Solid Waste Has Advantages and Disadvantages (3 of 5)

Trade-Offs

Sanitary Landfills

- **Advantages**
- Low operating costs Can handle large amounts of waste Filled land can be used for other purposes
- No shortage of landfill space in many areas

- **Disadvantages**
  - Noise, traffic, and dust
  - Releases greenhouse gases (methane and CO2) unless they are collected
  - Output approach that encourages waste production
  - Eventually leaks and can contaminate groundwater

Burying Solid Waste Has Advantages and Disadvantages (4 of 5)

- Open dumps
  - Widely used in less-developed countries
  - Open field or large pit

Burying Solid Waste Has Advantages and Disadvantages (5 of 5)

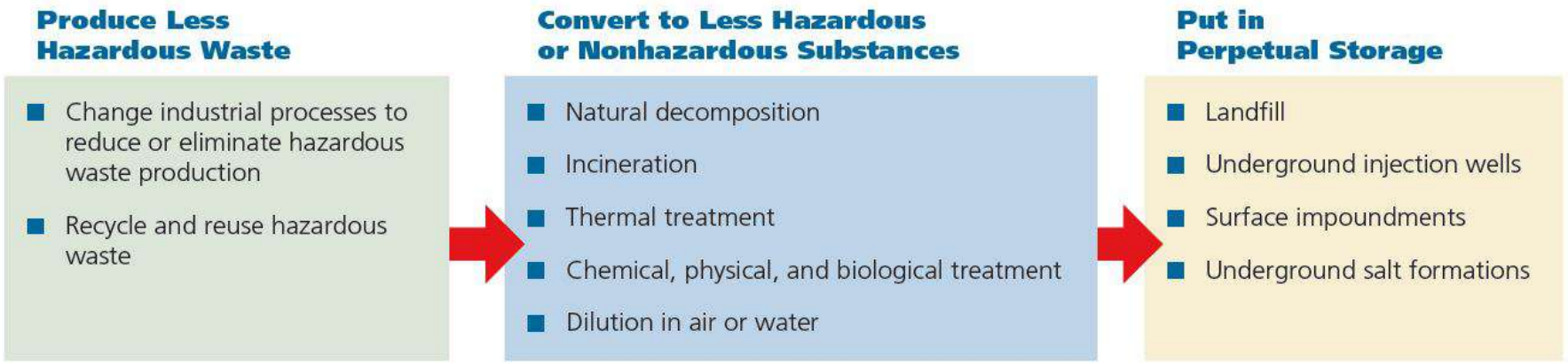
18.5 How Should We Deal with Hazardous Waste?

- Sustainable approach to hazardous waste
  - Produce less of it
  - Reuse or recycle it
  - Convert it to less-hazardous materials
  - Safely store what is left

Hazardous Waste Requires Special Handling (1 of 2)

- Best practices
  - Produce less
  - Convert as much as possible to less-hazardous substances
  - Put the rest in long-term safe storage

Hazardous Waste Requires Special Handling (2 of 2)



Integrated hazardous waste management: The U.S. National Academy of Sciences has suggested these priorities for dealing with hazardous waste.

Case Study: Recycling E-Waste (1 of 2)

- Much of the world's e-waste shipped to China
  - Hazardous working conditions
  - Includes child workers
- The United States produces roughly 50% of the world's e-waste
  - Recycles only 14%
- 13 states: manufacturers responsible for recycling electronic devices

Case Study: Recycling E-Waste (2 of 2)

James P. Blair/National Geographic Creative

Detoxifying Hazardous Wastes (1 of 2)

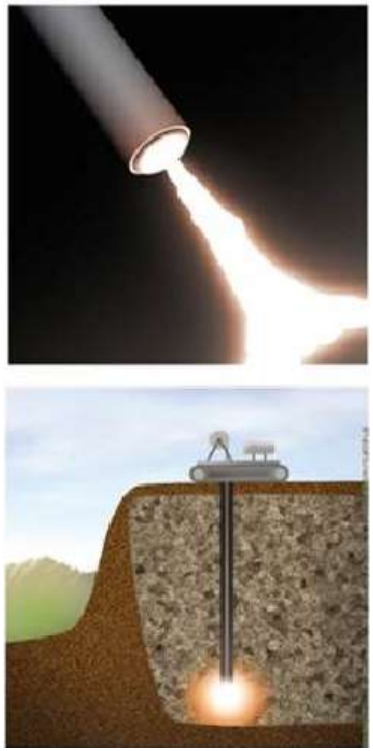
- Collect and then detoxify
  - Physical methods
  - Chemical methods
  - Bioremediation
  - Phytoremediation
- Plasma gasification
  - Incineration using a plasma arc torch

Detoxifying Hazardous Wastes (2 of 2)

Trade-Offs

Plasma Arc

- **Advantages**
  - Produces a mixture of CO and H2 that can be used as a fuel
  - Mobile. Easy to move to different sites
  - Produces no toxic ash



- **Disadvantages**
  - High cost
  - Produces CO_2 and CO
  - Can release particulates and chlorine gas
  - Can vaporize and release toxic metals and radioactive elements

Storing Hazardous Waste (1 of 4)

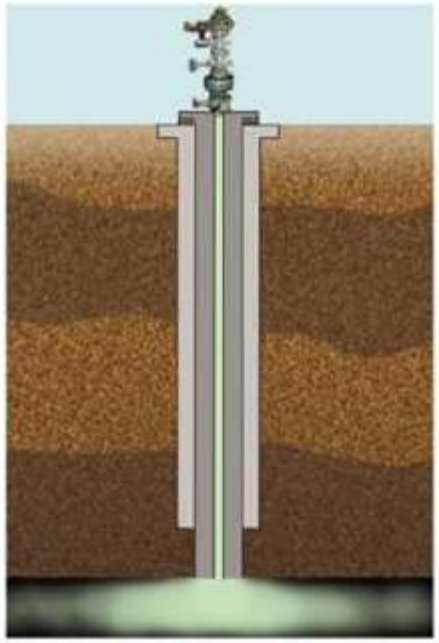
- Burial on land or long-term storage
  - Most widely used method today due to low cost
- Deep-well disposal
- Surface impoundments
  - Lined ponds, pits, or lagoons
- Secure hazardous waste landfills
  - Expensive

Storing Hazardous Waste (2 of 4)

Trade-Offs

Deep-Well Disposal

- **Advantages**
  - Safe if sites are chosen carefully
  - Wastes can often be retrieved
  - Low cost



- **Disadvantages**
  - Leaks can occur from corrosion of well casing
  - Emits CO_2 and other air pollutants
  - Output approach that encourages waste production

Storing Hazardous Waste (3 of 4)

Trade-Offs

Surface impoundments

- **Advantages**
  - Low cost
  - Wastes can often be retrieved
  - Can store wastes indefinitely with secure double liners

- **Disadvantages**
  - Watter pollution from leaking liners and overflows
  - Air pollution from volatile organic compounds
  - Output approach that encourages waste production

Storing Hazardous Waste (4 of 4)

What Can You Do?

Hazardous Waste

- Avoid using pesticides and other hazardous chemicals, or use them in the smallest amounts possible
- Use less harmful substances instead of commercial household cleaners. For example, use vinegar to polish metals, clean surfaces, and remove stains and mildew, and baking soda to clean utensils and to deodorize and remove stains.
- Do not dump pesticides, paints, solvents, oil, antifreeze, or other hazardous chemicals down the toilet, down the drain, into the ground, into the garbage, or down storm drains. Free hazardous waste disposal services are available in many cities.
- Do not throw old fluorescent lightbulbs (which contain mercury) into regular trash. Many communities and home product retailers offer free recycling of these bulbs.

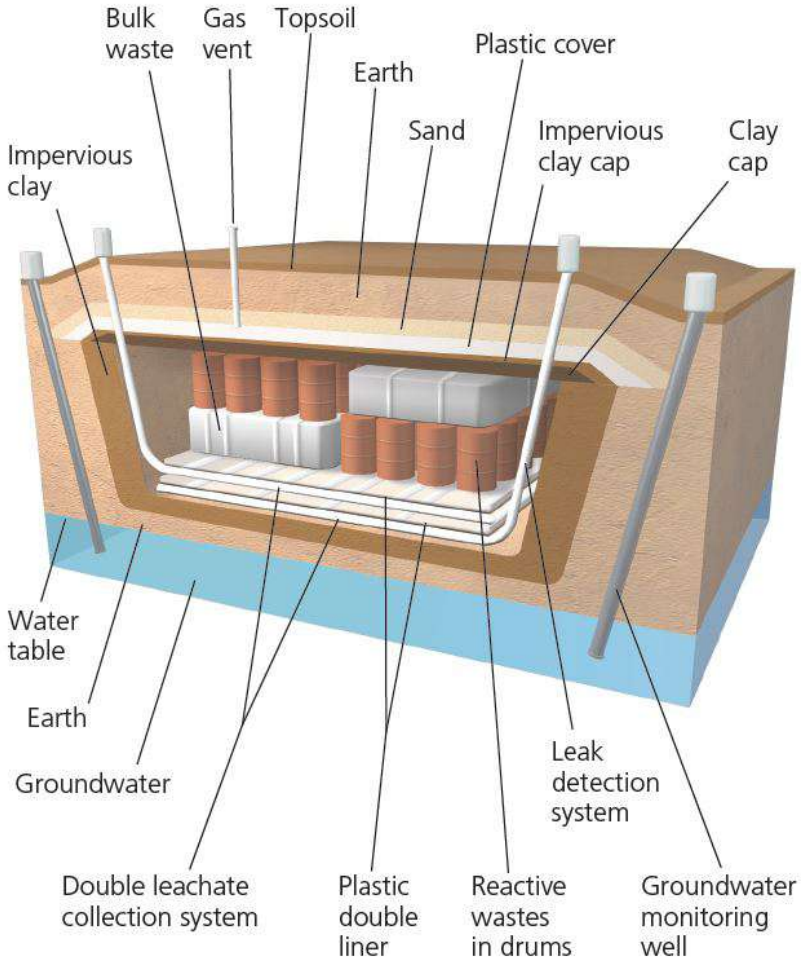
Case Study: Hazardous Waste Regulation in the United States (1 of 4)

- Toxic Substances Control Act
- 1976: Resource Conservation and Recovery Act (RCRA)
  - EPA sets standards and gives permits
  - Cradle to grave
  - Covers only 5% of hazardous waste produced in the United States

Case Study: Hazardous Waste Regulation in the United States (2 of 4)

- 1980: Comprehensive Environmental, Compensation, and Liability Act (CERCLA)
  - National Priorities List
    - 2016: 1323 Superfund sites; 391 cleaned
  - Pace of cleanup has slowed
    - Funding discontinued
- Laws encouraging the cleanup of brownfields
  - Abandoned industrial sites

Case Study: Hazardous Waste Regulation in the United States (3 of 4)



Hazardous wastes can be isolated and stored in a secure hazardous waste landfill.

Case Study: Hazardous Waste Regulation in the United States (4 of 4)

patrikslezak/Fotolia LLC

18.6 How Can We Shift to a Low-Waste Economy?

- Requirements of shifting to a low-waste economy
  - Reduce resource use
  - Reuse and recycle most solid and hazardous wastes
  - Must happen at local, national, and global levels

Citizens Can Take Action

- Many citizens have acted to oppose construction of:
  - Incinerators, landfills, treatment plants, and chemical plants
- Argument: something must be done with hazardous wastes
  - Counterargument: focus on producing less

Using International Treaties to Reduce Hazardous Waste

- 1992: Basel Convention
  - Bans participating countries from shipping hazardous waste to other countries
- 2000: Stockholm Convention on Persistent Organic Pollutants
- 2020: Sweden ban of hazardous chemicals will become effective
  - Places burden on industries to show chemicals are safe

Encouraging Reuse and Recycling

- Factors that hinder reuse and recycling
  - Market prices do not include harmful costs
  - Economic playing field is uneven
  - Demand for recycled materials fluctuates
- Governments can increase subsidies for using recycled materials
  - Require government purchase of recycled products
- Fee-per-bag waste collection system

Reuse and Recycling Present Economic Opportunities

- Yard sales, secondhand stores, eBay, and Craigslist
- Freecycle network
- Upcycling
  - Recycling materials into products of higher value

Making the Transition to Low-Waste Economies

- Zero-waste movement
  - Some restaurants, corporations, and others have dramatically lowered waste outputs
- Key principles
  - Everything is connected
  - There is no *away*
  - Producers and polluters should pay
  - We can mimic nature by reusing, recycling, composting, or exchanging

Case Study: Industrial Ecosystems: Copying Nature (1 of 2)

- Resource exchange webs
  - Waste as raw material
  - Ecoindustrial parks
- Two major steps of biomimicry
  - Observe how natural systems respond
  - Apply to human industrial systems

Case Study: Industrial Ecosystems: Copying Nature (2 of 2)