MILLER/SPOOLMAN

LIVING IN THE ENVIRONMENT

17TH

Chapter 21

Solid and Hazardous Waste

Core Case Study: E-waste—An Exploding Problem (1)

- Electronic waste, e-waste: fastest growing solid waste problem
- Most ends up in landfills and incinerators
- Composition includes
  - High-quality plastics
  - Valuable metals
  - Toxic and hazardous pollutants

Core Case Study: E-waste—An Exploding Problem (2)

- Shipped to other countries
  - What happens in China and India?
- International Basel Convention
  - Bans transferring hazardous wastes from developed countries to developing countries
- European Union
  - Cradle-to-grave approach

Core Case Study: E-waste—An Exploding Problem (3)

- What should be done?
  - Recycle
  - E-cycle
  - Reuse
  - Prevention approach: remove the toxic materials

Rapidly Growing E-Waste from Discarded Computers and Other Electronics

Fig. 21-1, p. 557

21-1 What Are Solid Waste and Hazardous Waste, and Why Are They Problems?

- ***Concept 21-1*** *Solid waste contributes to pollution and represents the unnecessary consumption of resources; hazardous waste contributes to pollution as well as to natural capital degradation, health problems, and premature deaths.*

We Throw Away Huge Amounts of Useful Things and Hazardous Materials (1)

- **Solid waste**
  - **Industrial solid waste**
    - Mines, farms, industries
  - **Municipal solid waste (MSW)**
    - Trash
  - **Hazardous waste (toxic waste)**
    - Threatens human health of the environment
    - Organic compounds
    - Toxic heavy metals
    - Radioactive waste

We Throw Away Huge Amounts of Useful Things and Hazardous Materials (2)

- 80–90% of hazardous wastes produced by developed countries
  - U.S. is the largest producer

- Why reduce solid wastes?
  1. ¾ of the materials are an unnecessary waste of the earth's resources
  2. Huge amounts of air pollution, greenhouse gases, and water pollution

What Harmful Chemicals Are in Your Home?

What Harmful Chemicals Are in Your Home?

Cleaning

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

Gardening

- Pesticides
- Weed killers
- Ant and rodent killers
- Flea powders

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

Automotive

- Gasoline
- Used motor oil
- Antifreeze
- Battery acid
- Brake and transmission fluid

Fig. 21-2, p. 559

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Stepped Art

Fig. 21-2, p. 559

Natural Capital Degradation: Solid Wastes Polluting a River in Indonesia

Fig. 21-3, p. 560

Solid Waste in the United States

- Leader in solid waste problem
  - What is thrown away?
- Leader in trash production, by weight, per person
- Recycling is helping

Total and Per Capita Production of Municipal Solid Waste in the U.S.

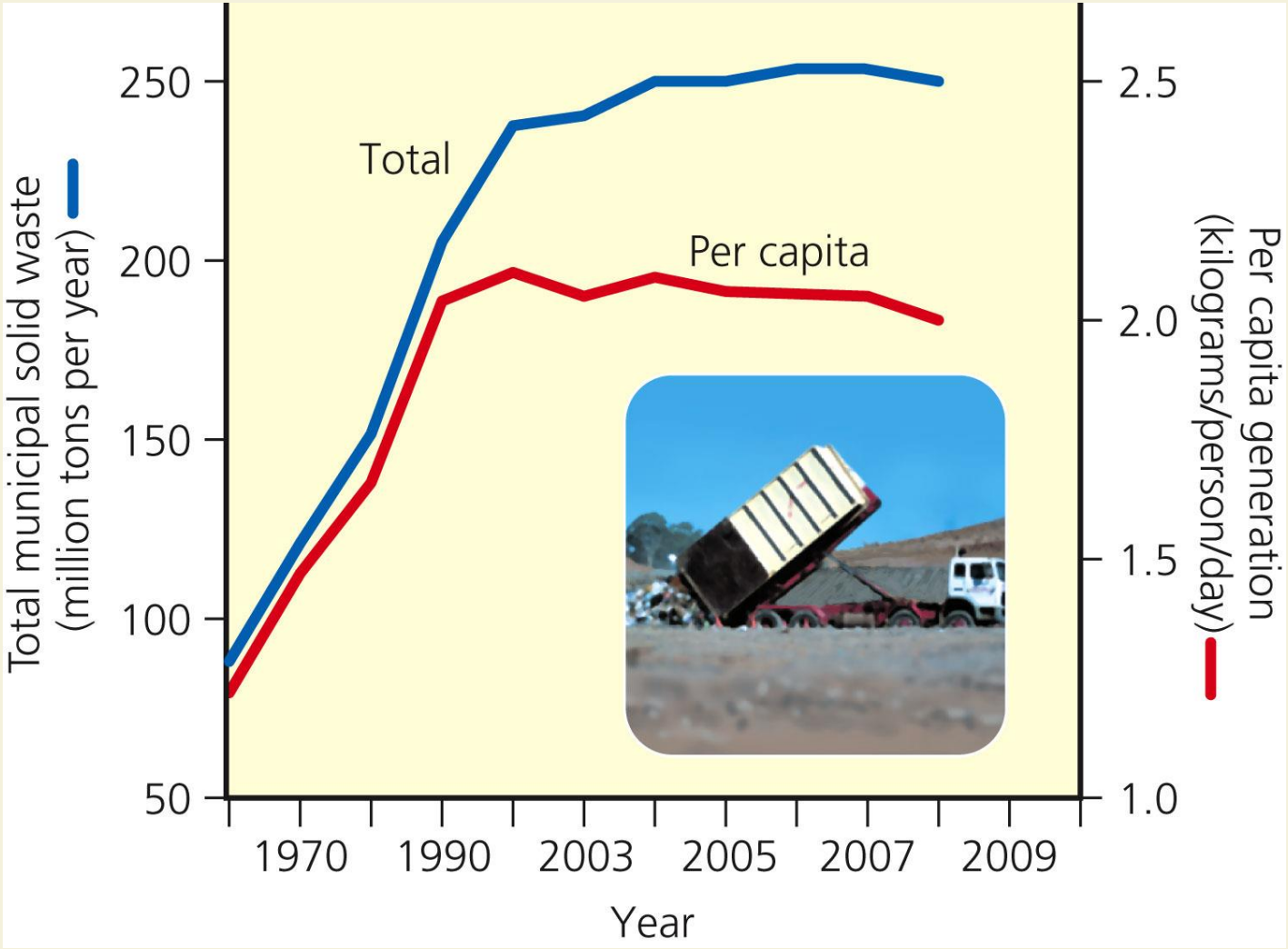


Fig. 21-4, p. 560

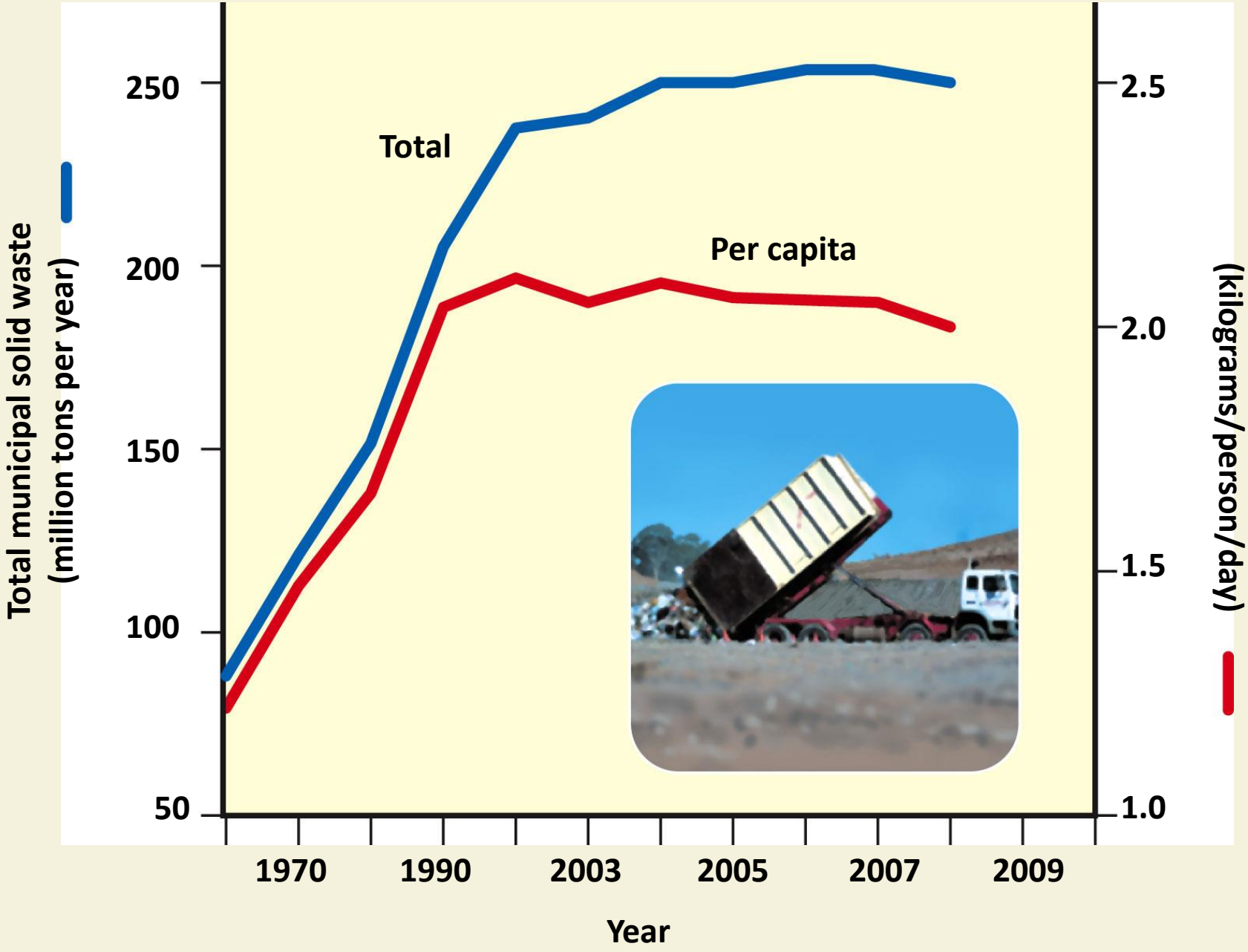

Total municipal solid waste (million tons per year)
250
200
150
100
50
Total
Per capita
2.5
2.0
1.5
1.0
Per capita generation (kilograms/person/day)
1970
1990
2003
2005
2007
2009
Year

Fig. 21-4, p. 560

Hundreds of Millions of Discarded Tires in a Dump in Colorado

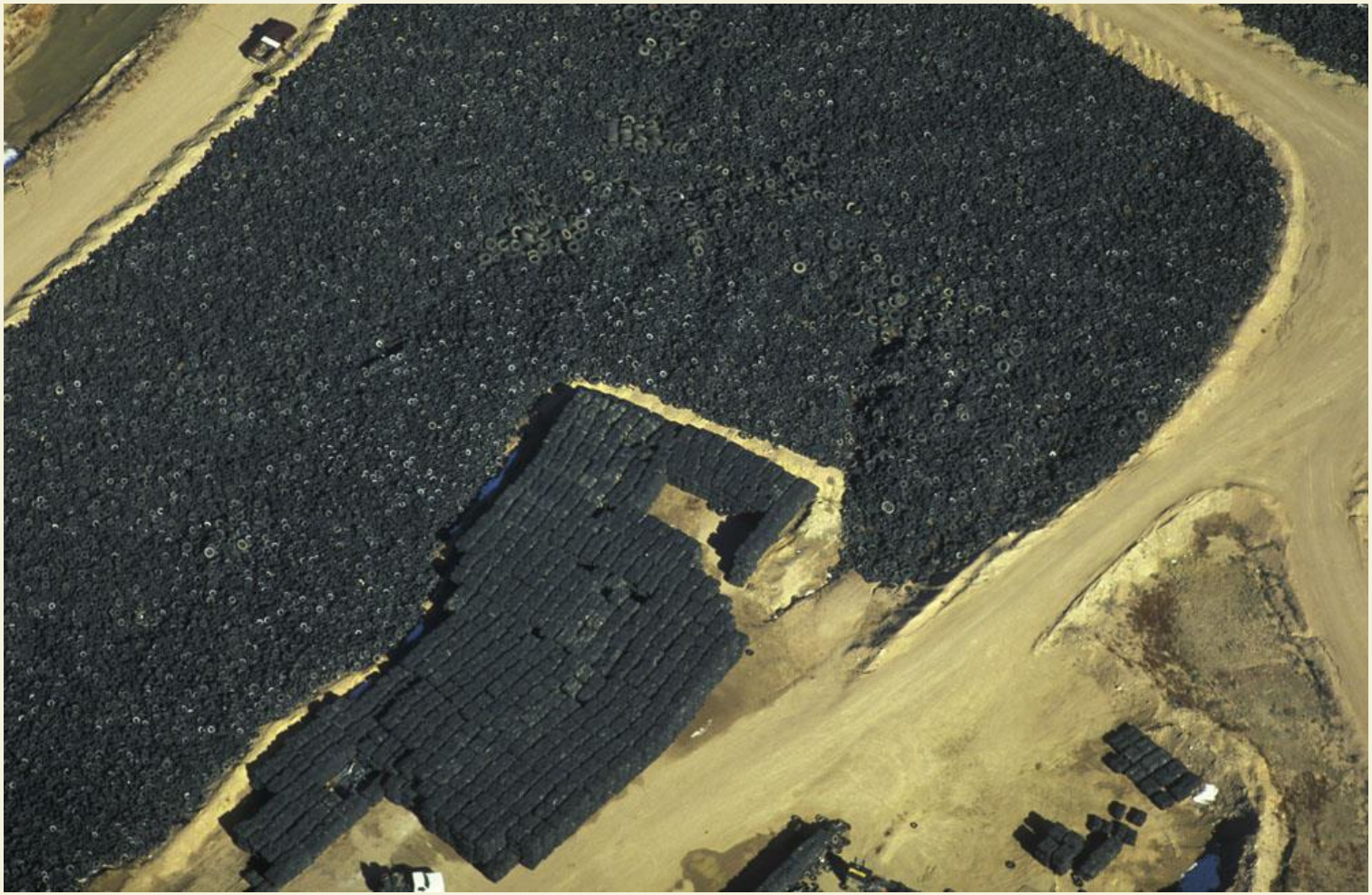


Fig. 21-5, p. 561

21-2 How Should We Deal with Solid Waste?

- ***Concept 21-2*** *A sustainable approach to solid waste is first to reduce it, then to reuse or recycle it, and finally to safely dispose of what is left.*

We Can Burn or Bury Solid Waste or Produce Less of It

- **Waste Management**
  - Reduce harm, but not amounts
- **Waste Reduction**
  - Use less and focus on reuse, recycle, compost
- **Integrated waste management**
  - Uses a variety of strategies

Integrated Waste Management

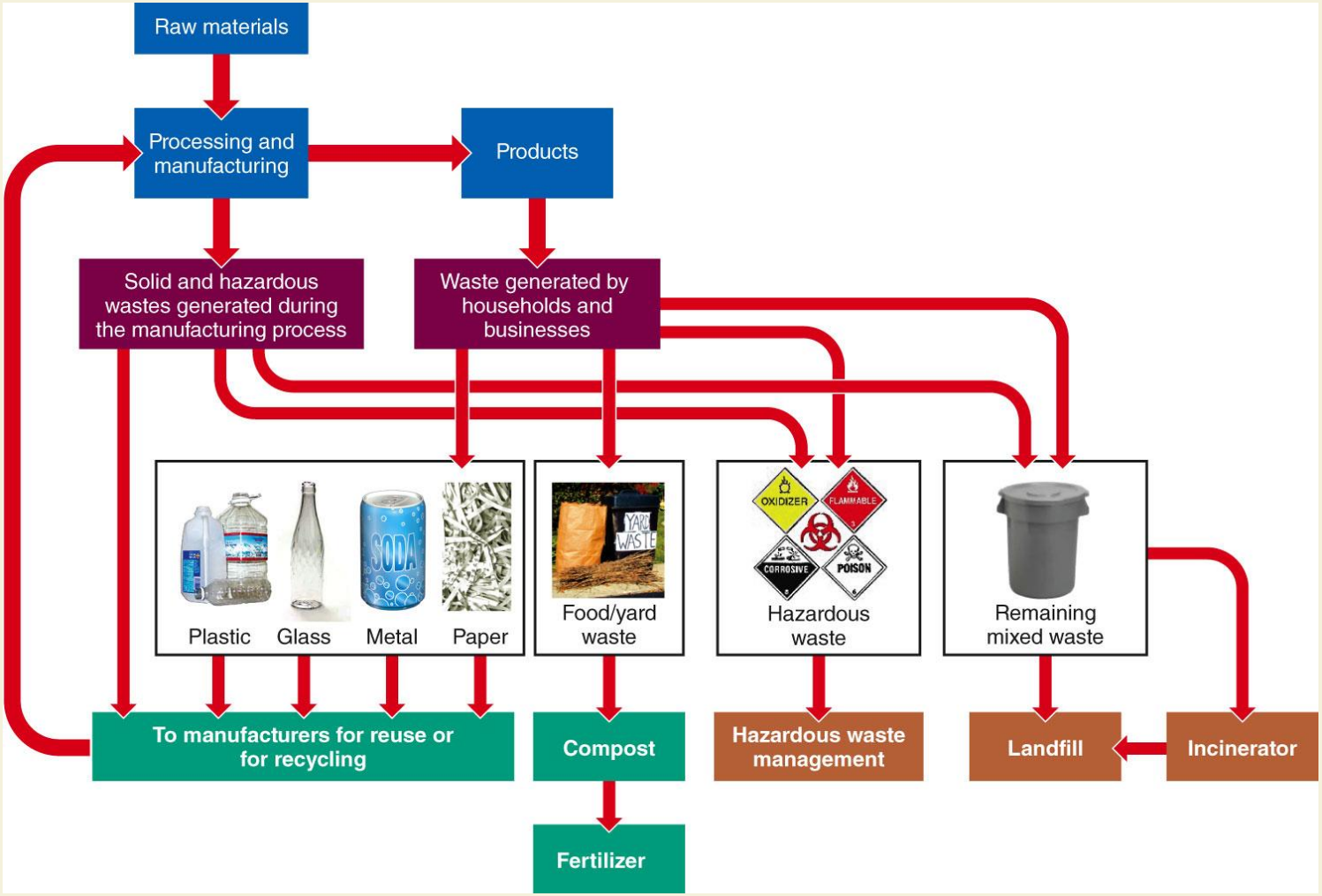


Fig. 21-6, p. 562

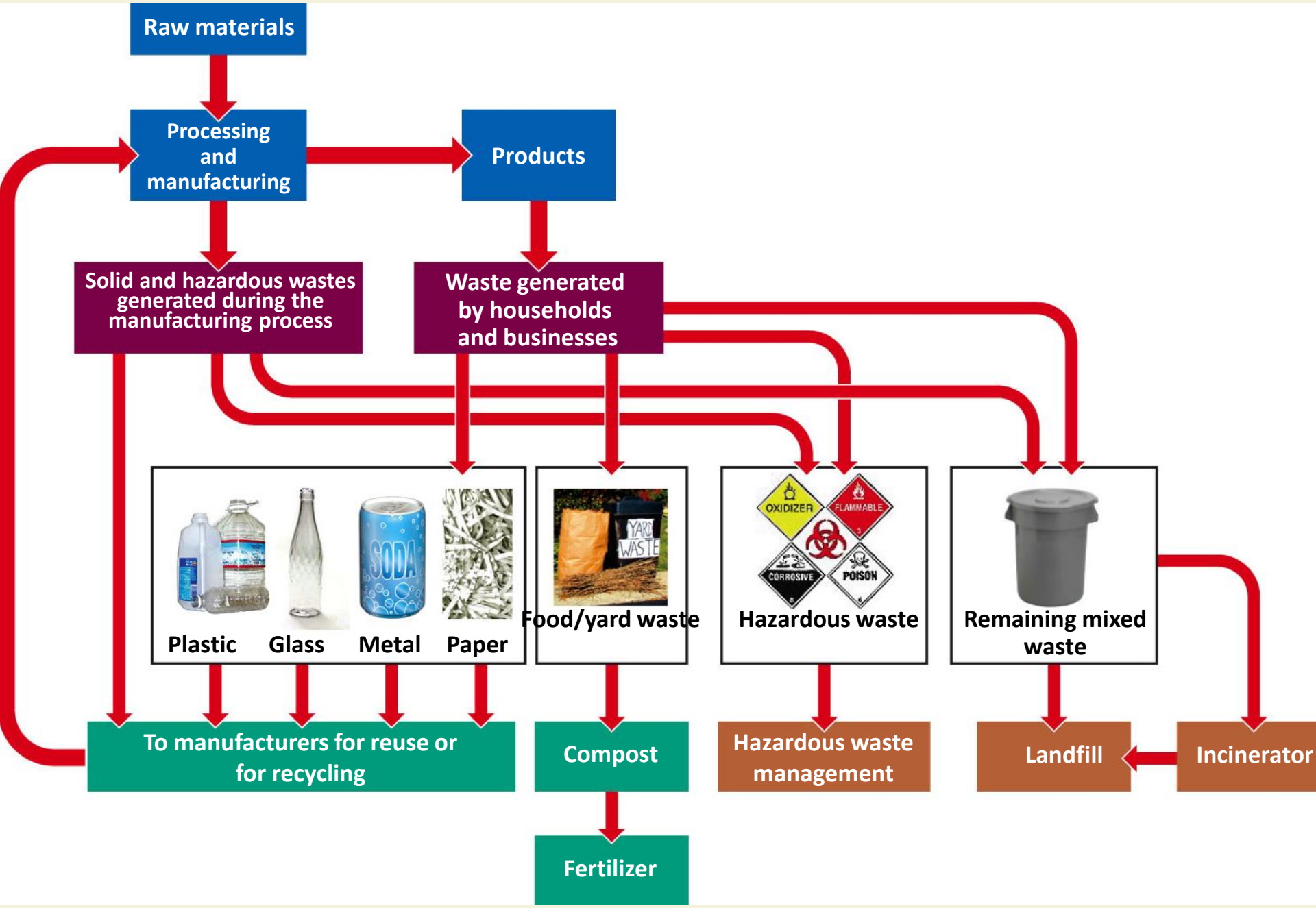

Raw materials
Processing and manufacturing
Products
Solid and hazardous wastes generated during the manufacturing process
Waste generated by households and businesses
SODA
Plastic
Glass
Metal
Paper
YARD WASTE
Food/yard waste
OXIDIZER
FLAMMABLE
CORROSIVE
POISON
Hazardous waste
Remaining mixed waste
To manufacturers for reuse or for recycling
Compost
Fertilizer
Hazardous waste management
Landfill
Incinerator

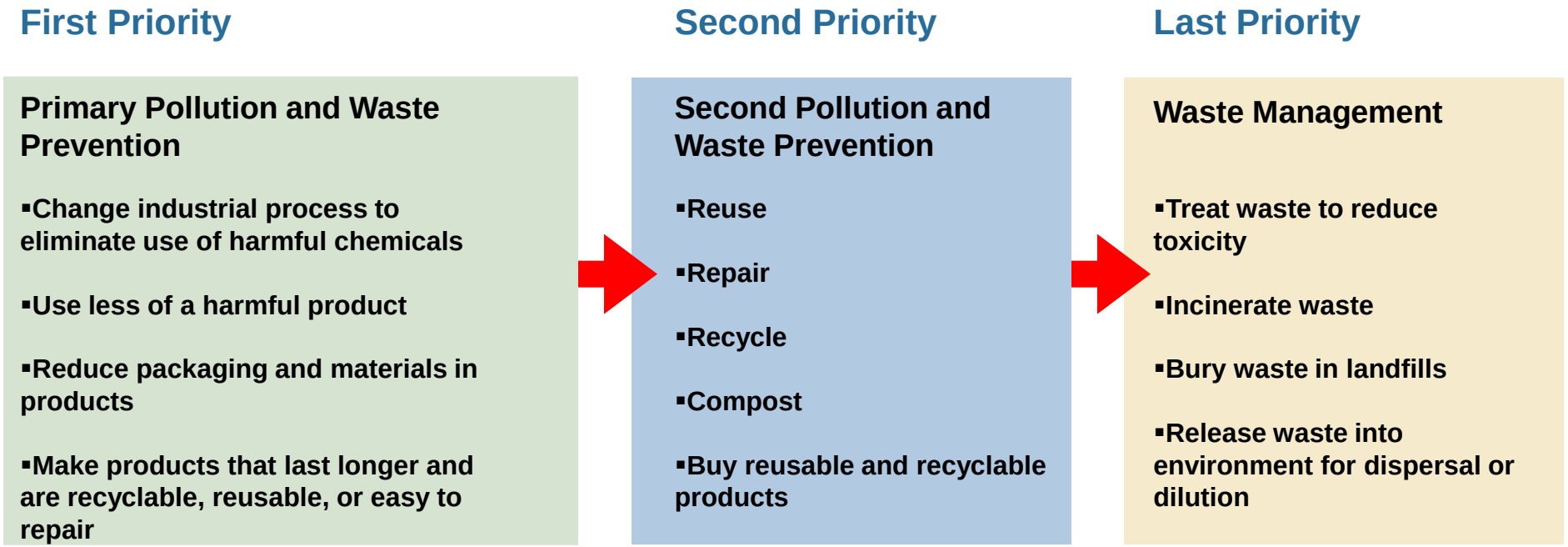
Fig. 21-6, p. 562

Integrated Waste Management: Priorities for Dealing with Solid Waste

Fig. 21-7, p. 562


First Priority
Second Priority
Last Priority
Primary Pollution and Waste Prevention
Change industrial process to eliminate use of harmful chemicals
Use less of a harmful product
Reduce packaging and materials in products
Make products that last longer and are recyclable, reusable, or easy to repair
Secondary Pollution and Waste Prevention
Reuse
Repair
Recycle
Compost
Buy reusable and recyclable products
Waste Management
Treat waste to reduce toxicity
Incinerate waste
Bury waste in landfills
Release waste into environment for dispersal or dilution

Fig. 21-7, p. 562



Stepped Art

Fig. 21-7, p. 562

Science Focus: Garbology

- William Rathje: analyzes garbage in landfills

- Landfills and trash decomposition
  - Much slower than previously thought

We Can Cut Solid Wastes by Reducing, Reusing, and Recycling (1)

- Waste reduction is based on
  - **Reduce**
  - **Reuse**
  - **Recycle**

We Can Cut Solid Wastes by Reducing, Reusing, and Recycling (2)

- Six strategies:
  1. Redesign manufacturing processes and products to use less material and energy
  2. Develop products that are easy to repair, reuse, remanufacture, compost, or recycle
  3. Eliminate or reduce unnecessary packaging
  4. Use fee-per-bag waste collection systems
  5. Establish cradle-to grave responsibility
  6. Restructure urban transportation systems

What Can You Do? Solid Waste

Fig. 21-8, p. 563

21-3 Why Are Reusing and Recycling Materials So Important?

- ***Concept 21-3*** *Reusing items decreases the consumption of matter and energy resources, and reduces pollution and natural capital degradation; recycling does so to a lesser degree.*

New or Recycle?

	Energy Required (MJ/kg)	
	New:	Recycled:
Glass	25	25
Steel	50	26
Aluminum	250	8
Copper	60	7
Paper	24	15

ENERGY REQUIRED IN THE PRODUCTION OF VARIOUS MATERIALS

Reuse: Important Way to Reduce Solid Waste, Pollution, and Save Money

- Reuse: clean and use materials over and over
- Downside of reuse in developing countries
  - Salvaging poor exposed to toxins
- Flea markets, yard sales, second-hand stores, eBay, Craigslist, freecycle.org
- Rechargeable batteries

Case Study: Use of Refillable Containers

- Reuse and recycle
  - Refillable glass beverage bottles
  - Refillable soft drink bottles made of polyethylene terephthalate (PET) plastic
  - Bottle deposits create jobs and reduce litter and landfill amounts

- Paper, plastic, or reusable cloth bags
  - Pros
  - Cons

What Can You Do? Reuse

Fig. 21-9, p. 565

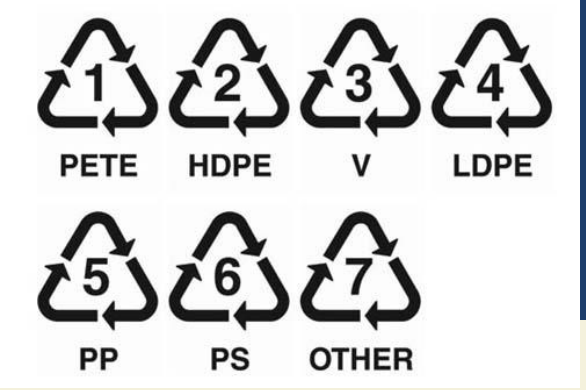
There Are Two Types of Recycling (1)

- **Primary, closed-loop recycling**
  - Materials recycled into same type: aluminum cans
- **Secondary recycling**
  - Materials converted to other products: tires
- Types of wastes that can be recycled
  - Preconsumer: internal waste
  - Postconsumer: external waste

There Are Two Types of Recycling (2)

- Do items actually get recycled?
- What are the numbers?

Types of Plastic Polymers



- Only similar types can be recycled together. Must be sorted at the recycling facility.
- high-density polyethylene (HDPE)
  - Milk bottles and water bottles are made from HDPE
- polyethylene terephthalate (PET) is called thermoplastic.
  - soda bottles are made from PET.
- Commonly used plastic usually not recycled: low-density polyethylene (LDPE).
  - used in sandwich and shopping bags.
- The $$ of raw materials determines how effectively materials can be recycled.
  - For example, when the price of oil (the raw material for plastics) is low, it is usually cheaper to produce products from new plastic, than to recycle old plastic.

Plastic Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
	Polyethylene Terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars
	High Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas	Milk, juice and water bottles; trash and retail bags.
	Polyvinyl Chloride (V)	Versatility, clarity, ease of blending, strength, toughness	Juice bottles; cling films; PVC piping
	Low Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups and plates.
	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; "Styrofoam"; disposable cups, plates, trays and cutlery; disposable take-away containers;
	Other (often polycarbonate or ABS)	Dependent on polymers or combination or polymers	Beverage bottles; baby milk bottles; electronic casing.

We Can Mix or Separate Household Solid Wastes for Recycling (1)

- Materials-recovery facilities (MRFs)
  - Can encourage increased trash production
- Source separation
  - Pay-as-you-throw
  - Fee-per-bag
- Which program is more cost effective?
- Which is friendlier to the environment?

We Can Mix or Separate Household Solid Wastes for Recycling (2)

- Composting
  - Individual
  - Municipal
- Benefits
- San Francisco, 2009
- Edmonton, Alberta, Canada

Backyard Composter Drum: Bacteria Convert Kitchen Waste into Compost

Fig. 21-10, p. 566

Case Study: Recycling Paper

- Production of paper versus recycled paper
  - Energy use: world's fifth largest consumer
  - Water use
  - Pollution
- Countries that lead recycling efforts
- Replacement of chlorine-based bleaching chemicals with H_2O_2 or O_2

Case Study: Recycling Plastics

- Plastics: composed of resins created from oil and natural gas
- Most containers discarded: 4% recycled
- Litter: beaches, oceans
  - Kills wildlife
  - Gets into food chain and seafood

Discarded Solid Waste Litters Beaches

Fig. 21-11, p. 568

Individuals Matter: Mike Biddle's Contribution to Recycling Plastics

- Mike Biddle and Trip Allen: MBA Polymers, Inc.
- Leaders in plastic recycling
- Plants in
  - U.S.
  - China
  - Australia

Science Focus: Bioplastics (1)

- Plastics from soybeans: not a new concept
- Key to bioplastics: catalysts that speed reactions
- Sources
  - Corn
  - Soy
  - Sugarcane

Science Focus: Bioplastics (2)

- Sources cont…
  - Switchgrass
  - Chicken feathers
  - Some garbage
  - CO_2 from coal-burning plant emissions

- Benefits: lighter, stronger, cheaper, and biodegradable

Recycling Has Advantages and Disadvantages

- Advantages

- Disadvantages

Trade-Offs: Recycling

Trade-Offs

Recycling

Advantages

Reduces energy and mineral use and air and water pollution

Reduces greenhouse gas emissions

Reduces solid waste

Can save landfill space

Disadvantages

Can cost more than burying in areas with ample landfill space

Reduces profits for landfill and incinerator owners

Source separation inconvenient for some

Fig. 21-12, p. 569

Trade-Offs

Recycling

Advantages

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Reduces greenhouse gas emissions

Reduces solid waste

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Fig. 21-12, p. 569

We Can Encourage Reuse and Recycling (1)

- What hinders reuse and recycling?
  1. Market prices don't include harmful costs associated with production, use, discarding
  2. Recycling industries get less favorable government treatment than large industries do
  3. Prices for recycled materials fluctuate

We Can Encourage Reuse and Recycling (2)

- Encourage reuse and recycling
  - Government
    - Increase subsidies and tax breaks for using such products
    - Decrease subsidies and tax breaks for making items from virgin resources
  - Fee-per-bag collection
  - New laws
  - Citizen pressure

21-4 The Advantages and Disadvantages of Burning or Burying Solid Waste

- ***Concept 21-4*** *Technologies for burning and burying solid wastes are well developed, but burning contributes to air and water pollution and greenhouse gas emissions, and buried wastes eventually contribute to the pollution and degradation of land and water resources.*

Burning Solid Waste Has Advantages and Disadvantages

- Waste-to-energy incinerators
- 600 globally
  - Most in Great Britain
- Advantages
- Disadvantages

Solutions: A Waste-to-Energy Incinerator with Pollution Controls

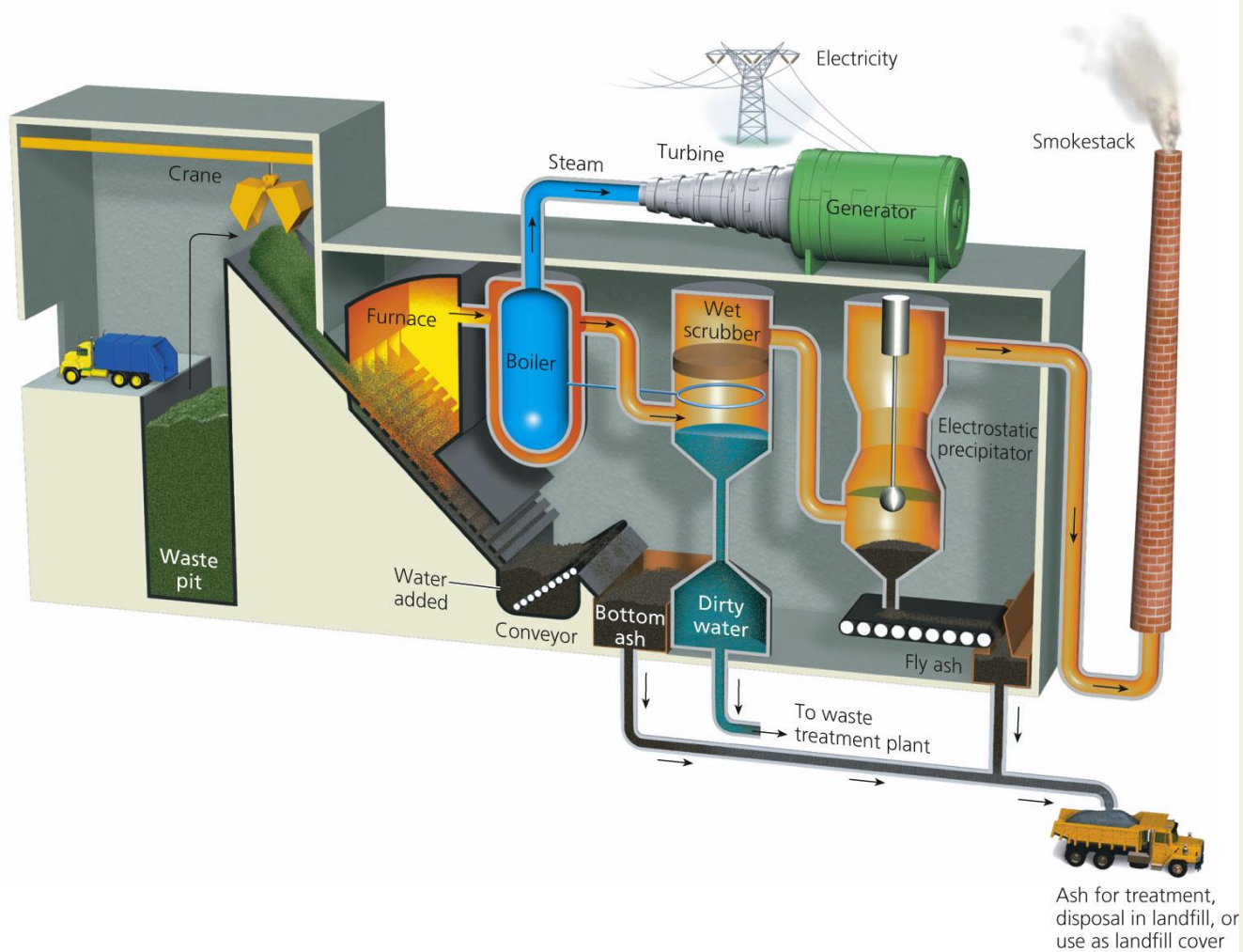

Fig. 21-13, p. 571

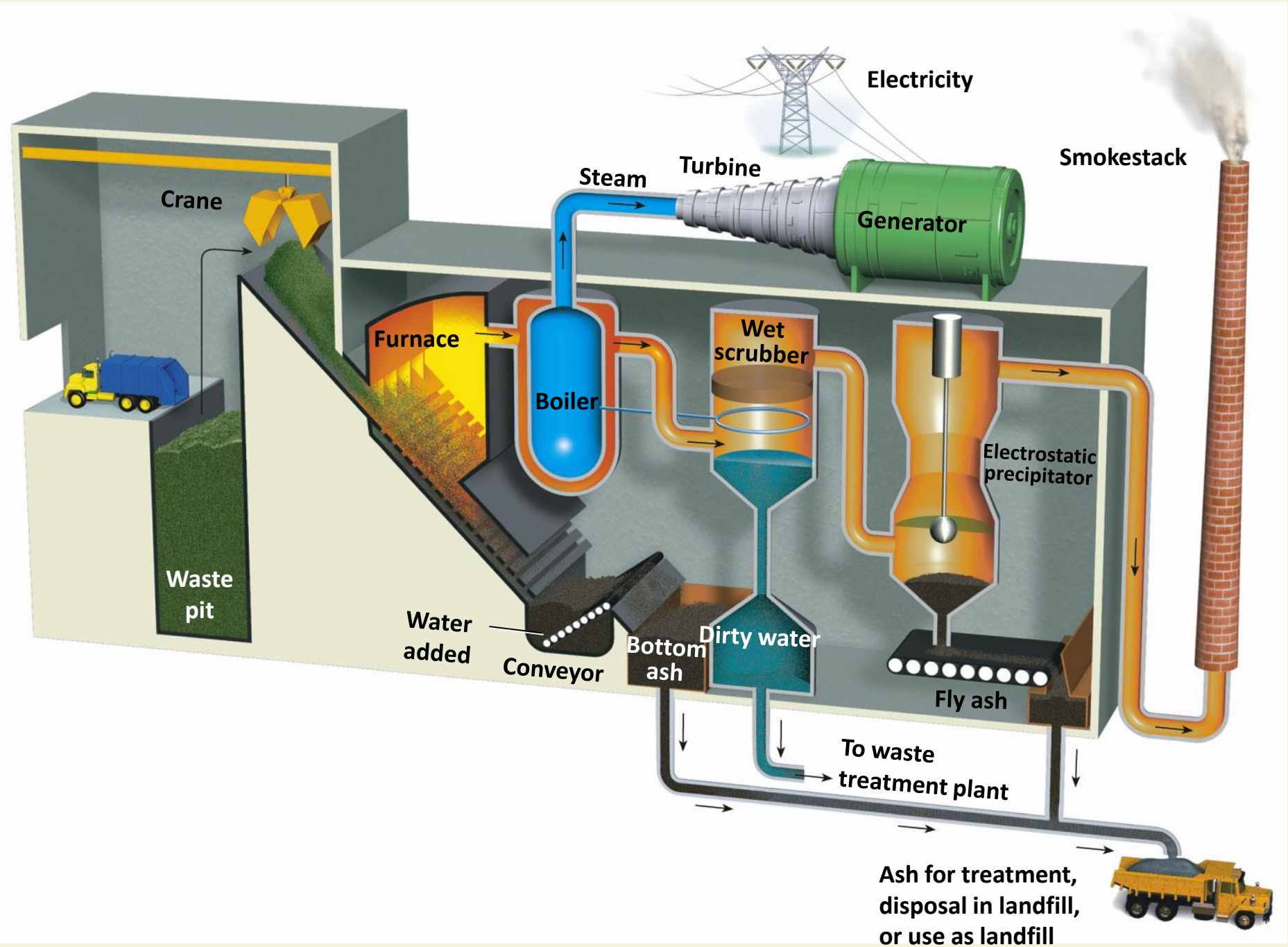

Fig. 21-13, p. 571

Trade-Offs: Waste-to-Energy Incineration

Trade-Offs

Waste-to-Energy Incineration

Advantages	Disadvantages
Reduces trash volume	Expensive to build
Produces energy	Produces a hazardous waste
Concentrates hazardous substances into ash for burial	Emits some CO_2 and other air pollutants
Sale of energy reduces cost	Encourages waste production

Fig. 21-14, p. 571

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 CO_2 and other air pollutants

Encourages waste production

Fig. 21-14, p. 571

Burying Solid Waste Has Advantages and Disadvantages

- Open dumps
  - Widely used in less-developed countries
  - Rare in developed countries

- Sanitary landfills

Solutions: State-of-the-Art Sanitary Landfill

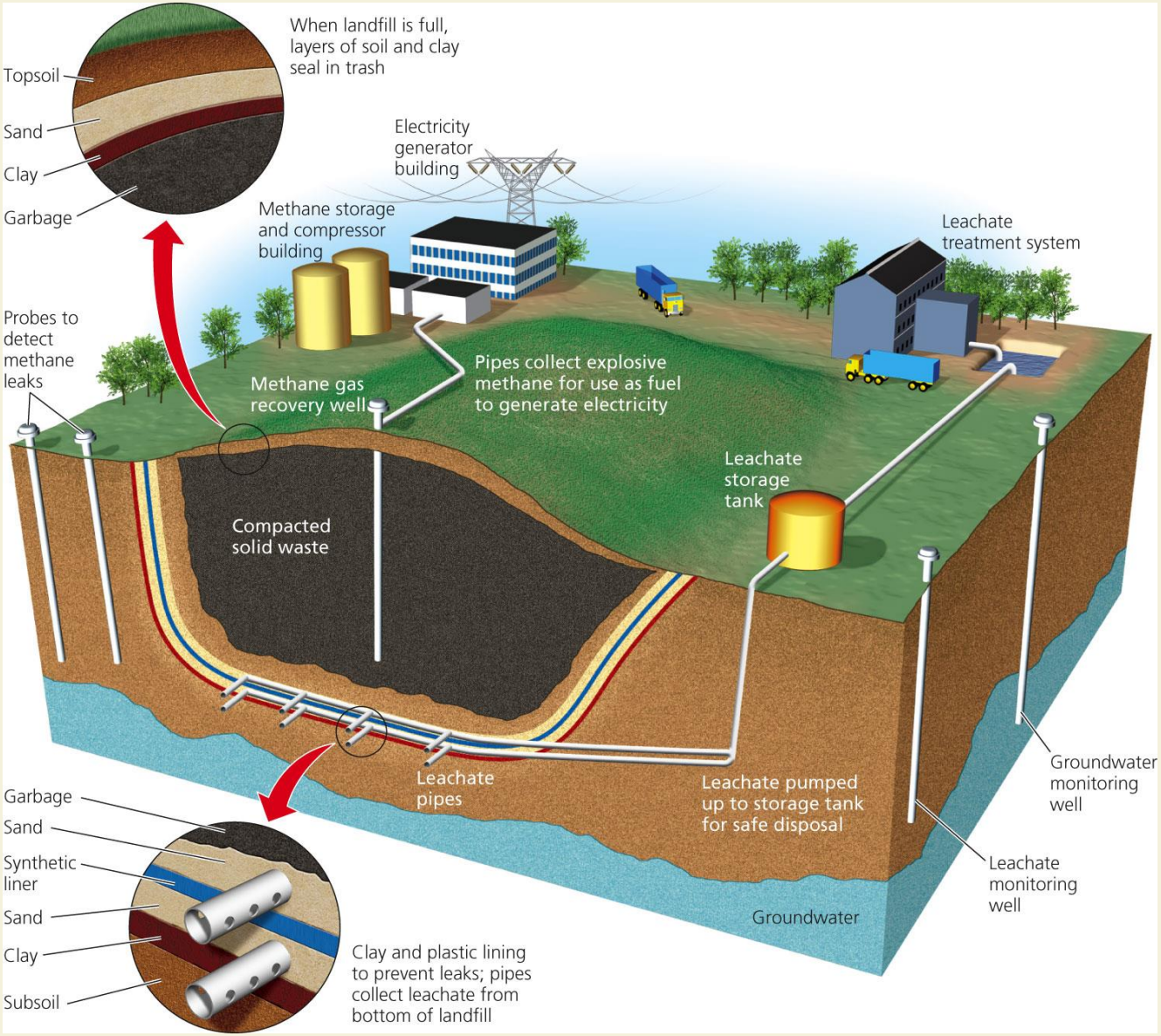

Fig. 21-15, p. 572

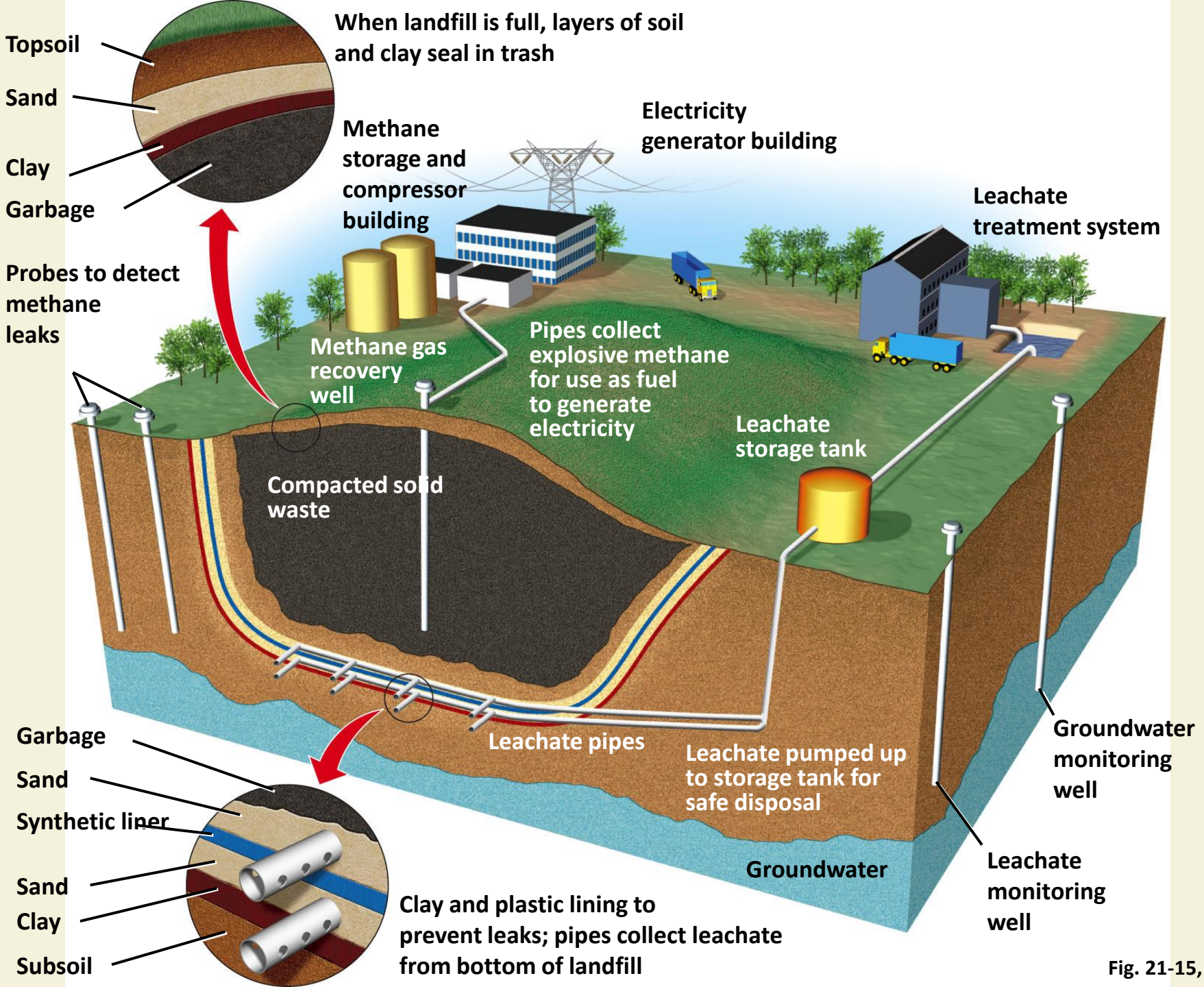

Fig. 21-15, p. 572

Trade-Offs: Sanitary Landfills

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 CO_2) unless they are collected

Output approach that encourages waste production

Eventually leaks and can contaminate groundwater

Fig. 21-16, p. 572

Trade-Offs

Sanitary Landfills

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Fig. 21-16, p. 572

21-5 How Should We Deal with Hazardous Waste?

- ***Concept 21-5*** *A sustainable approach to hazardous waste is first to produce less of it, then to reuse or recycle it, then to convert it to less hazardous materials, and finally, to safely store what is left.*

We Can Use Integrated Management of Hazardous Waste

- Integrated management of hazardous wastes
  - Produce less
  - Convert to less hazardous substances
  - Rest in long-term safe storage

- Increased use for postconsumer hazardous waste

Integrated Hazardous Waste Management

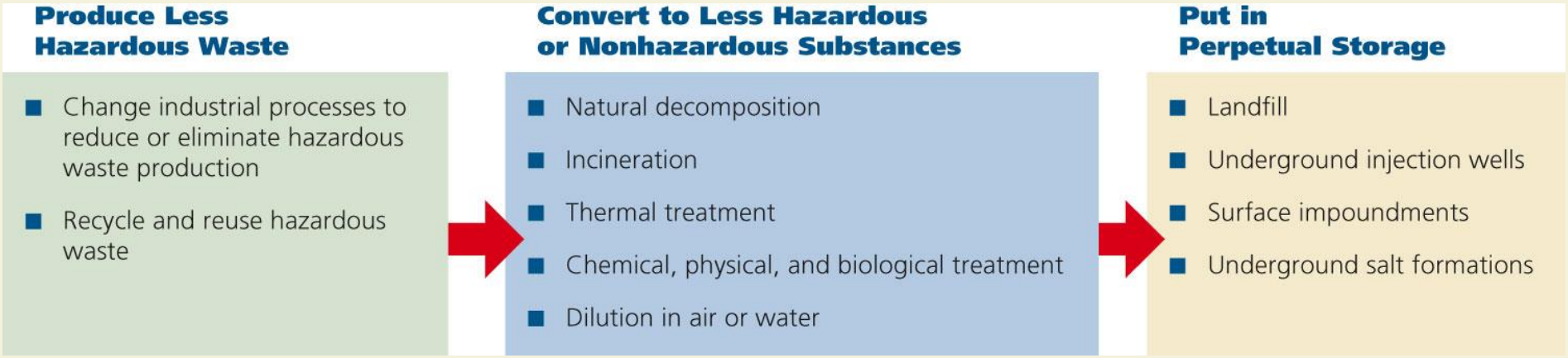


Fig. 21-17, p. 573

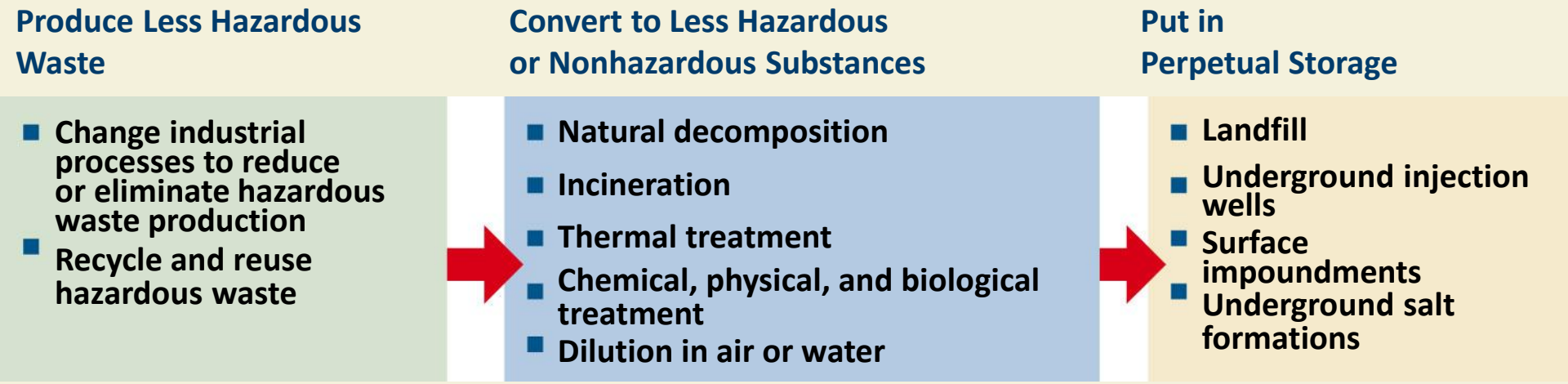


Fig. 21-17, p. 573

Produce Less Hazardous Waste

- Change industrial processes to reduce or eliminate hazardous waste production
- Recycle and reuse hazardous waste

Convert to Less Hazardous or Nonhazardous Substances

- Natural decomposition
- Incineration
- Thermal treatment
- Chemical, physical, and biological treatment
- Dilution in air or water

Put in Perpetual Storage

- Landfill
- Underground injection wells
- Surface impoundments
- Underground salt formations

Stepped Art

Fig. 21-17, p. 573

Case Study: Recycling E-Waste

- 70% goes to China
  - Hazardous working conditions
  - Includes child workers
- Reduce toxic components in electronics
- Dell and HP take recycle their products
- Europe has high-tech smelters with strict standards

Guiyu, China

- 70% of world's e-waste ends up here
- Dioxin levels are 86 TIMES safe limits

What is Dioxin?

- Dioxins and furans are some of the most toxic chemicals known to science. A draft report released for public comment in September 1994 by the US Environmental Protection Agency clearly describes dioxin as a serious public health threat. The public health impact of dioxin may rival the impact that DDT had on public health in the 1960's. According to the EPA report, not only does there appear to be no "safe" level of exposure to dioxin, but levels of dioxin and dioxin-like chemicals have been found in the general US population that are "at or near levels associated with adverse health effects."
- Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD. The toxicity of other dioxins and chemicals like PCBs that act like dioxin are measured in relation to TCDD. Dioxin is formed as an unintentional by-product of many industrial processes involving chlorine such as waste incineration, chemical and pesticide manufacturing and pulp and paper bleaching. Dioxin was the primary toxic component of Agent Orange, was found at Love Canal in Niagara Falls, NY and was the basis for evacuations at Times Beach, MO and Seveso, Italy.
- Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators of various sorts and also from backyard burn-barrels. Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

What does Dioxin do?

- Causes cancer, can also cause severe reproductive and developmental problems (at levels 100 times lower than those associated with its cancer causing effects). Dioxin is well-known for its ability to damage the immune system and interfere with hormonal systems.
- Dioxin exposure has been linked to birth defects, inability to maintain pregnancy, decreased fertility, reduced sperm counts, endometriosis, diabetes, learning disabilities, immune system suppression, lung problems, skin disorders, lowered testosterone levels and much more.

Where do we get Dioxin?

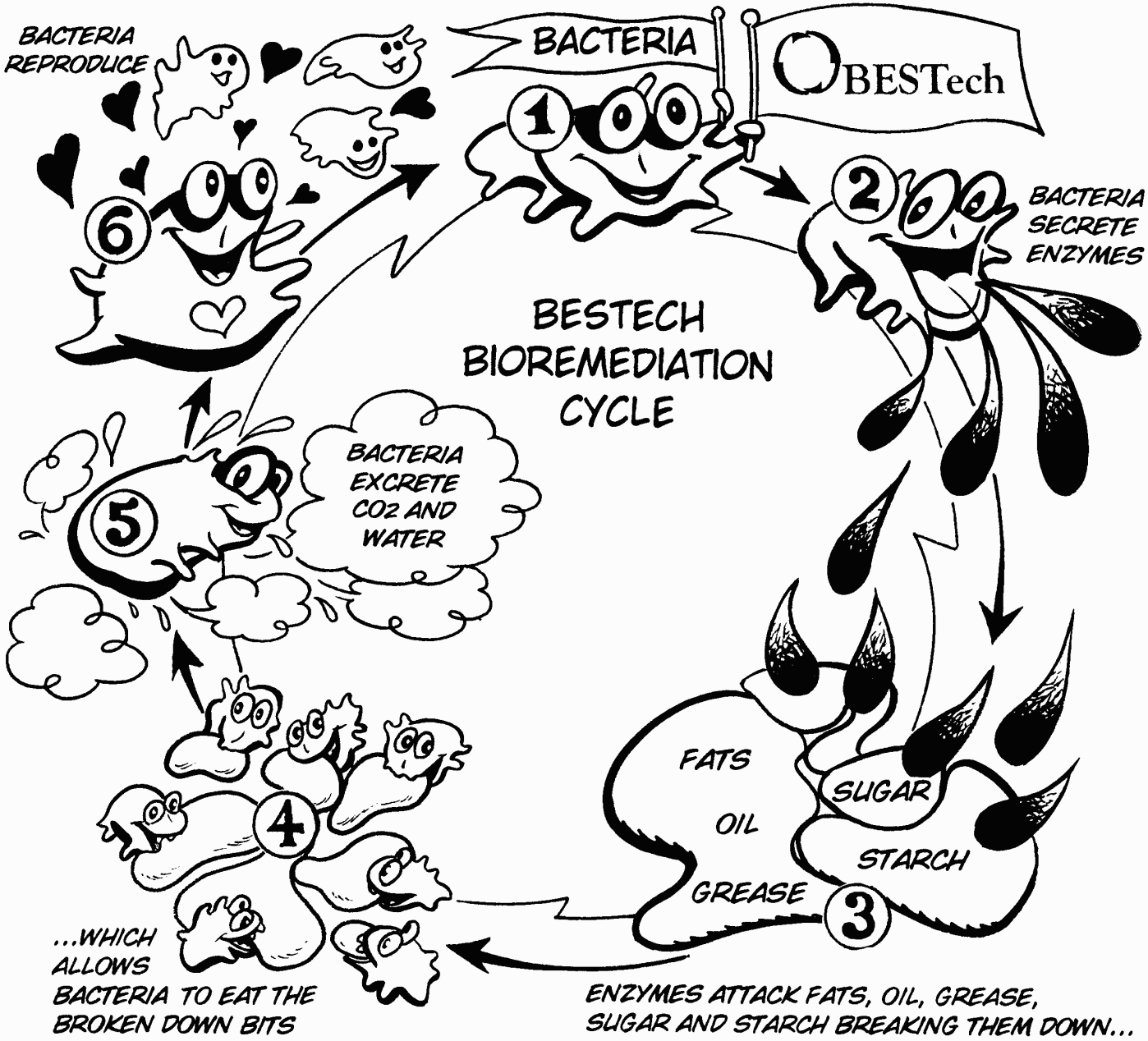
- The major sources of dioxin are in our diet. Since dioxin is fat-soluble, it bioaccumulates, climbing up the food chain. **A North American eating a typical North American diet will receive 93% of their dioxin exposure from meat and dairy products** (23% is from milk and dairy alone; the other large sources of exposure are beef, fish, pork, poultry and eggs). In fish, these toxins bioaccumulate up the food chain so that dioxin levels in fish are 100,000 times that of the surrounding environment. **The best way to avoid dioxin exposure is to reduce or eliminate your consumption of meat and dairy products by adopting a vegan diet.** According to a May 2001 study of dioxin in foods, "The category with the lowest [dioxin] level was a simulated vegan diet, with 0.09 ppt.... Blood dioxin levels in pure vegans have also been found to be very low in comparison with the general population, indicating a lower contribution of these foods to human dioxin body burden."

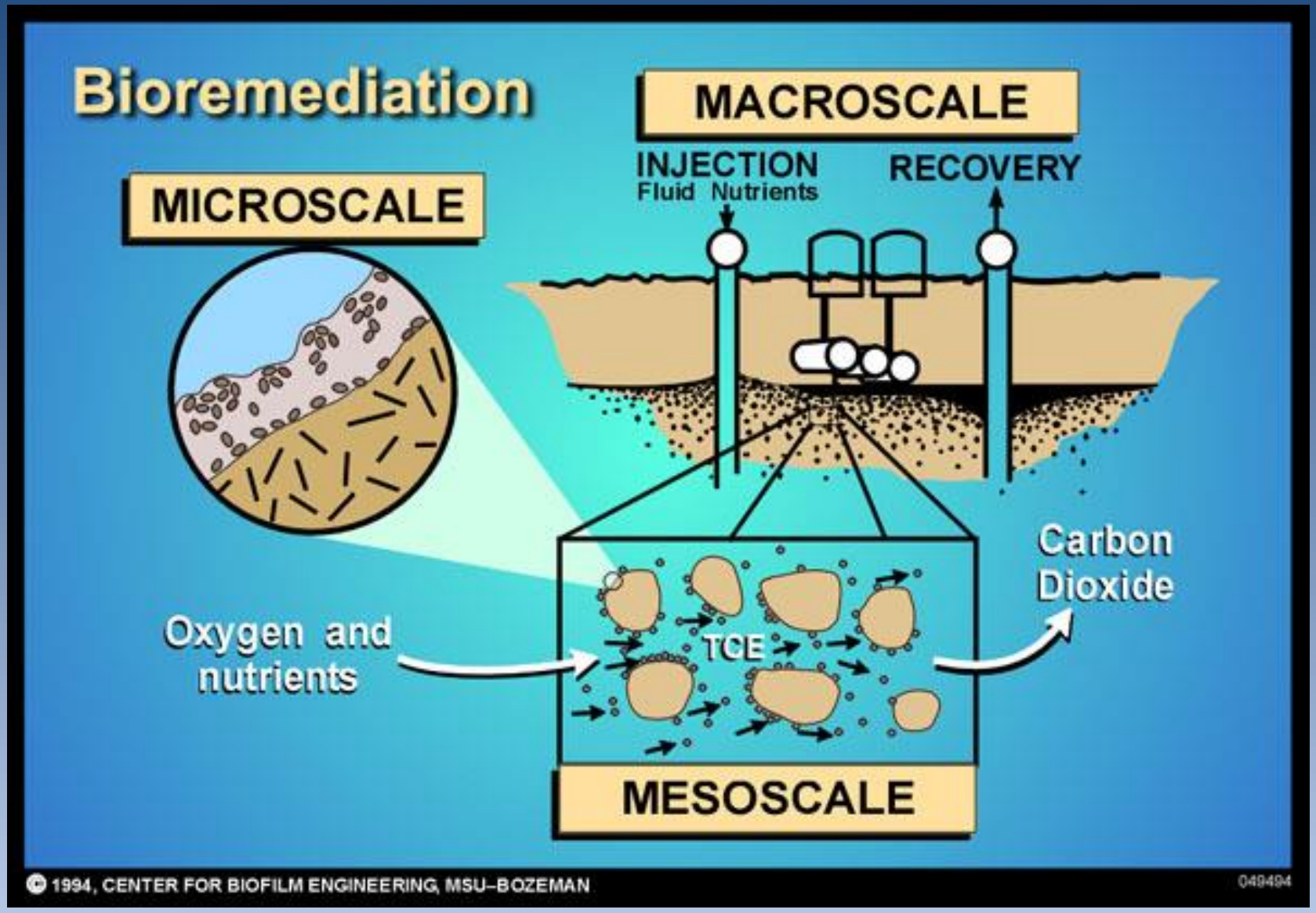
1-800-recycling.com

- http://1800recycling.com/find/recycling-locations?zip=33143

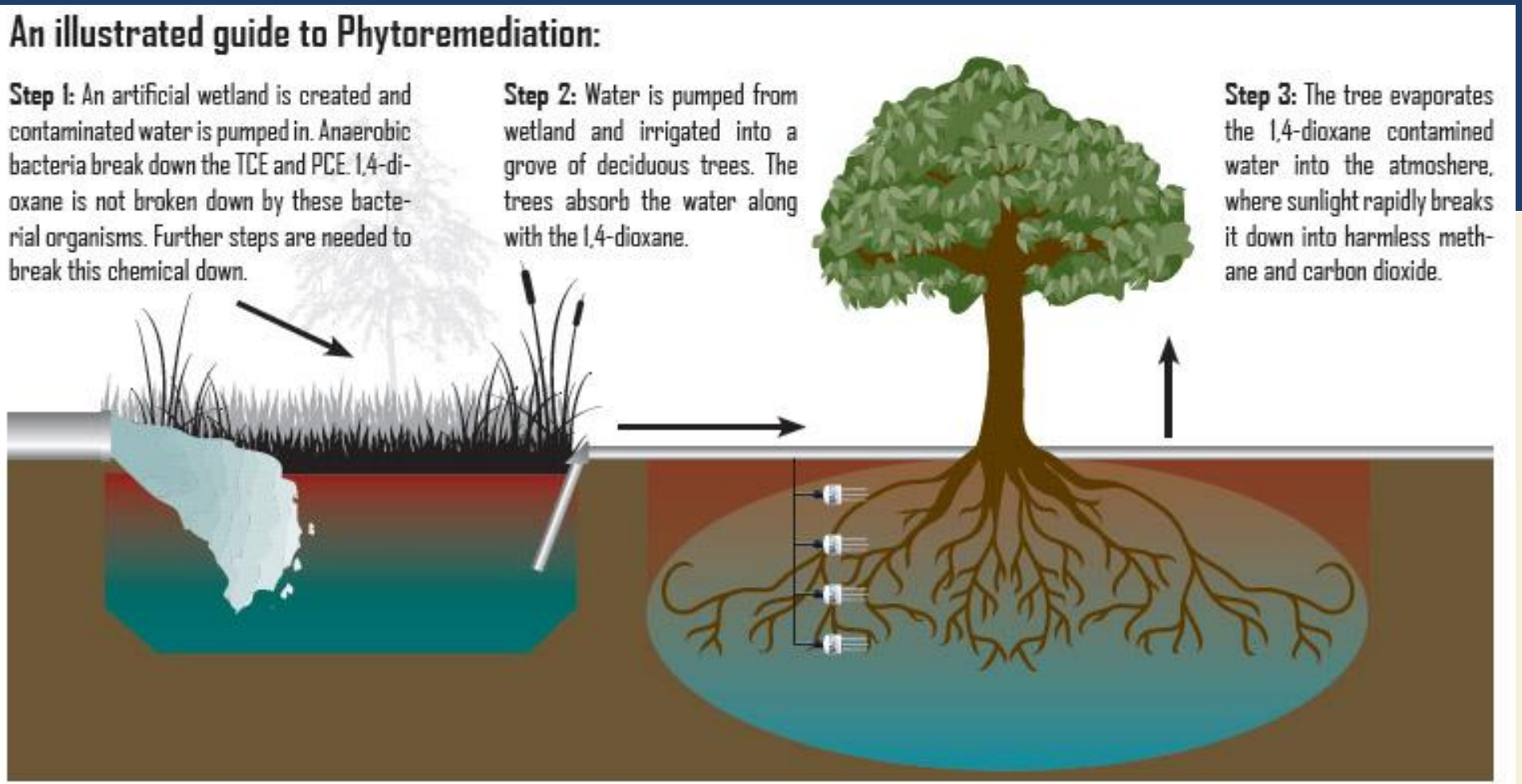
We Can Detoxify Hazardous Wastes

- Collect and then detoxify
  - Physical methods
  - Chemical methods
  - Use nanomagnets
  - Bioremediation
  - Phytoremediation
- Incineration
- Using a plasma arc torch





Organic solvents, PCBs, pesticides, oil → chloride salts



- Sunflowers – radioactives
- Willows – organic contaminants
- Poplars – oil spills
- Indian mustard/ brake fern – toxic metals (lead, arsenic)

Solutions: Phytoremediation

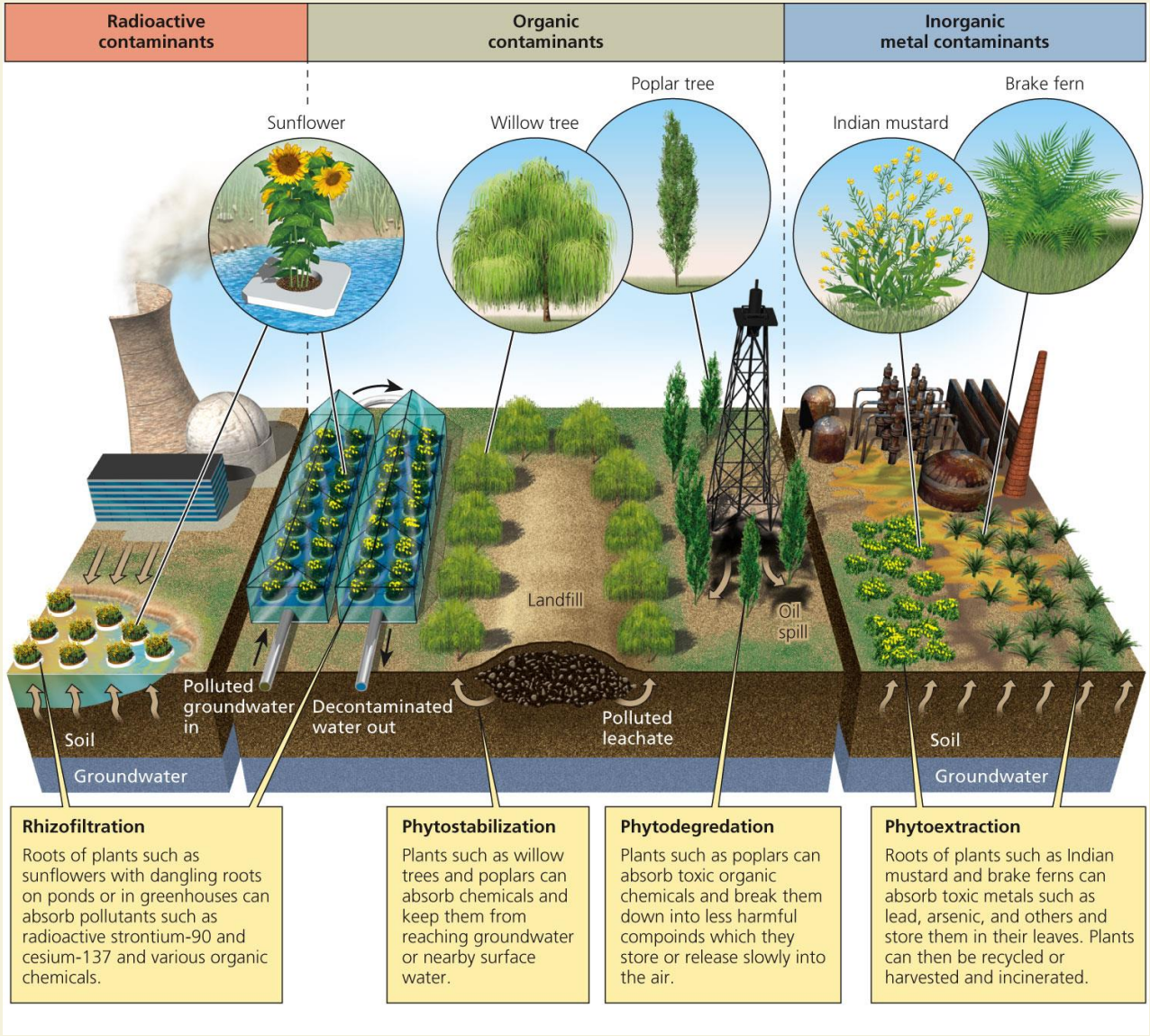


Fig. 21-18, p. 575

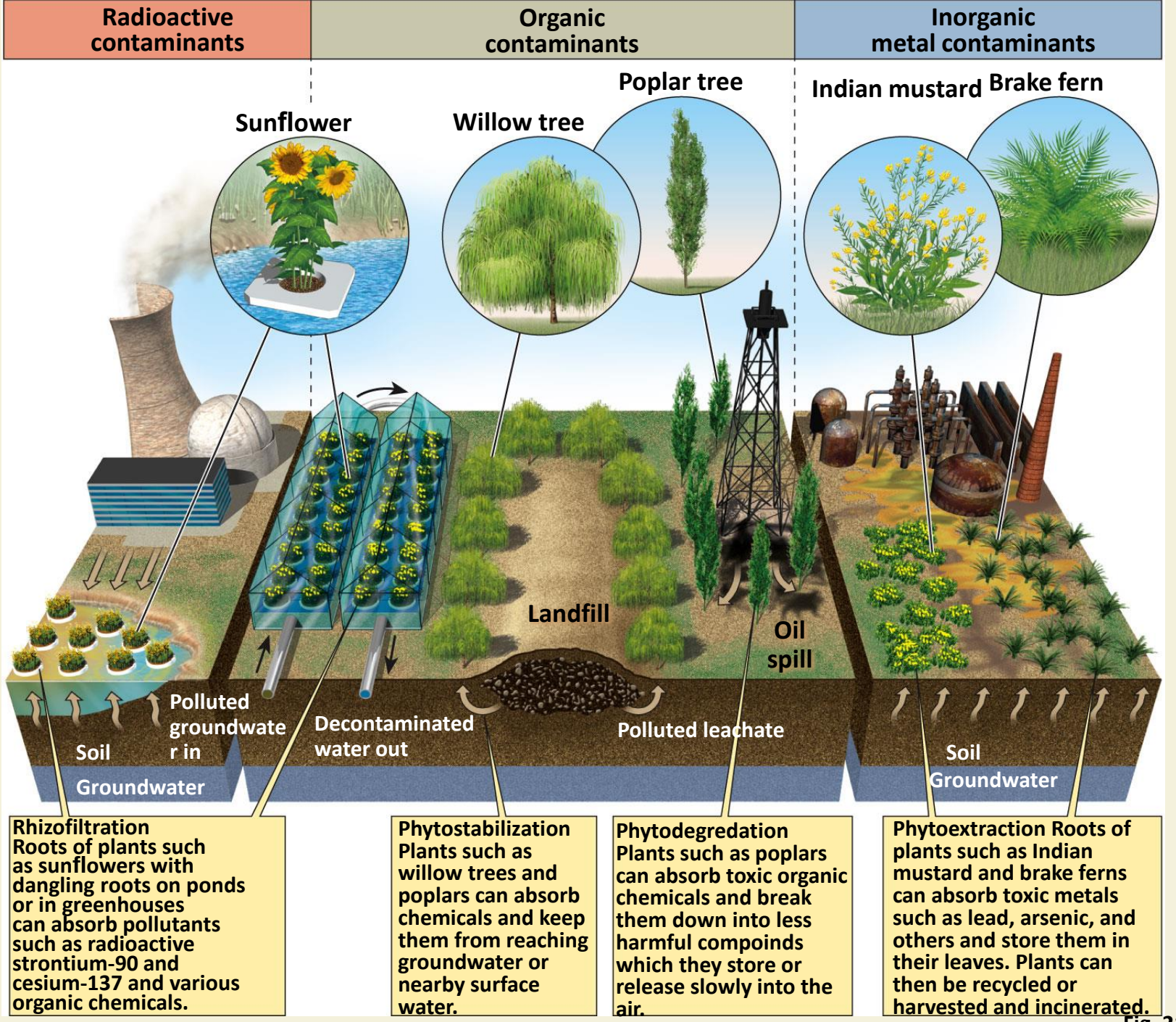


Fig. 21-18, p. 575

Trade-Offs: Plasma Arc

Trade-Offs

Plasma Arc

Advantages

Small

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

Fig. 21-19, p. 576

We Can Store Some Forms of Hazardous Waste (1)

- Burial on land or long-term storage
  - Last resort only
- Deep-well disposal
  - 64% of hazardous liquid wastes in the U.S.

Trade-Offs: Deep-Well Disposal

Trade-Offs

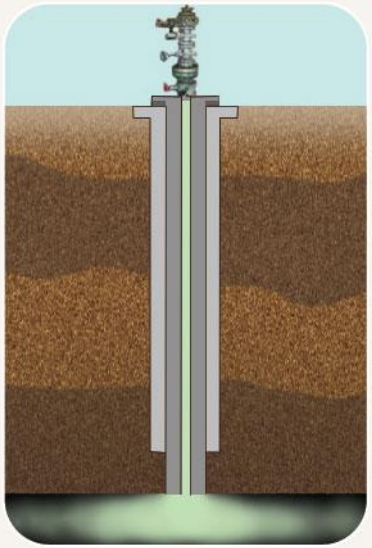
Deep-Well Disposal

Advantages

Safe if sites are chosen carefully

Wastes can often be retrieved

Low cost



Disadvantages

Leaks from corrosion of well casing

Emits CO_2 and other air pollutants

Output approach that encourages waste production

Fig. 21-20, p. 576

We Can Store Some Forms of Hazardous Waste (2)

- Surface impoundments
  - Lined ponds or pits
- Secure hazardous landfills

Surface Impoundment in Niagara Falls, New York

Fig. 21-21, p. 577

Trade-Offs Surface Impoundments

Trade-Offs

Surface Impoundments

Advantages

Low cost

Wastes can often be retrieved

Can store wastes indefinitely with secure double liners

Disadvantages

Groundwater contamination from leaking liners (and overflow from flooding)

Air pollution from volatile organic compounds

Output approach that encourages waste production

Fig. 21-22, p. 577

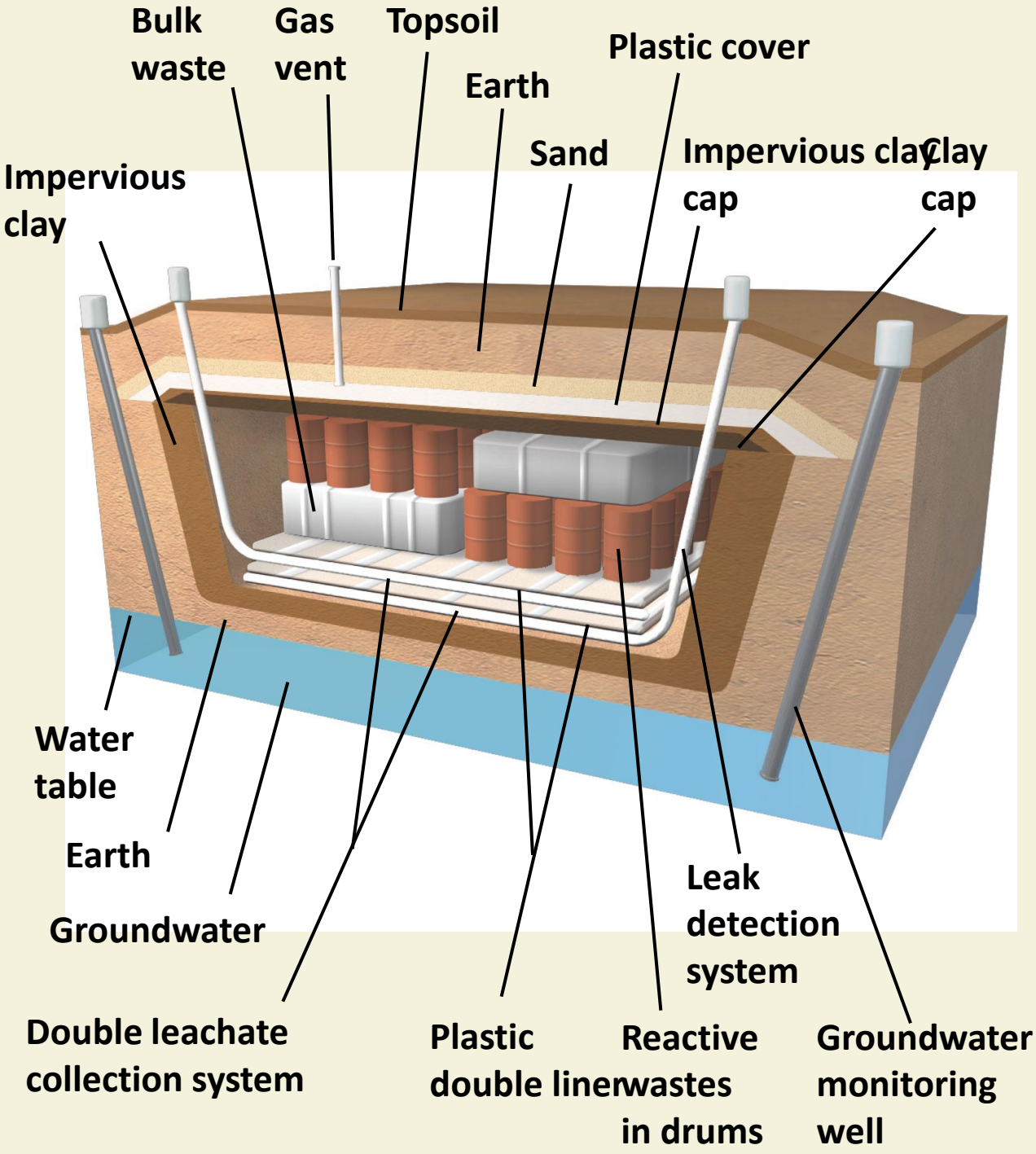


Fig. 21-23, p. 577

What Can You Do? Hazardous Waste

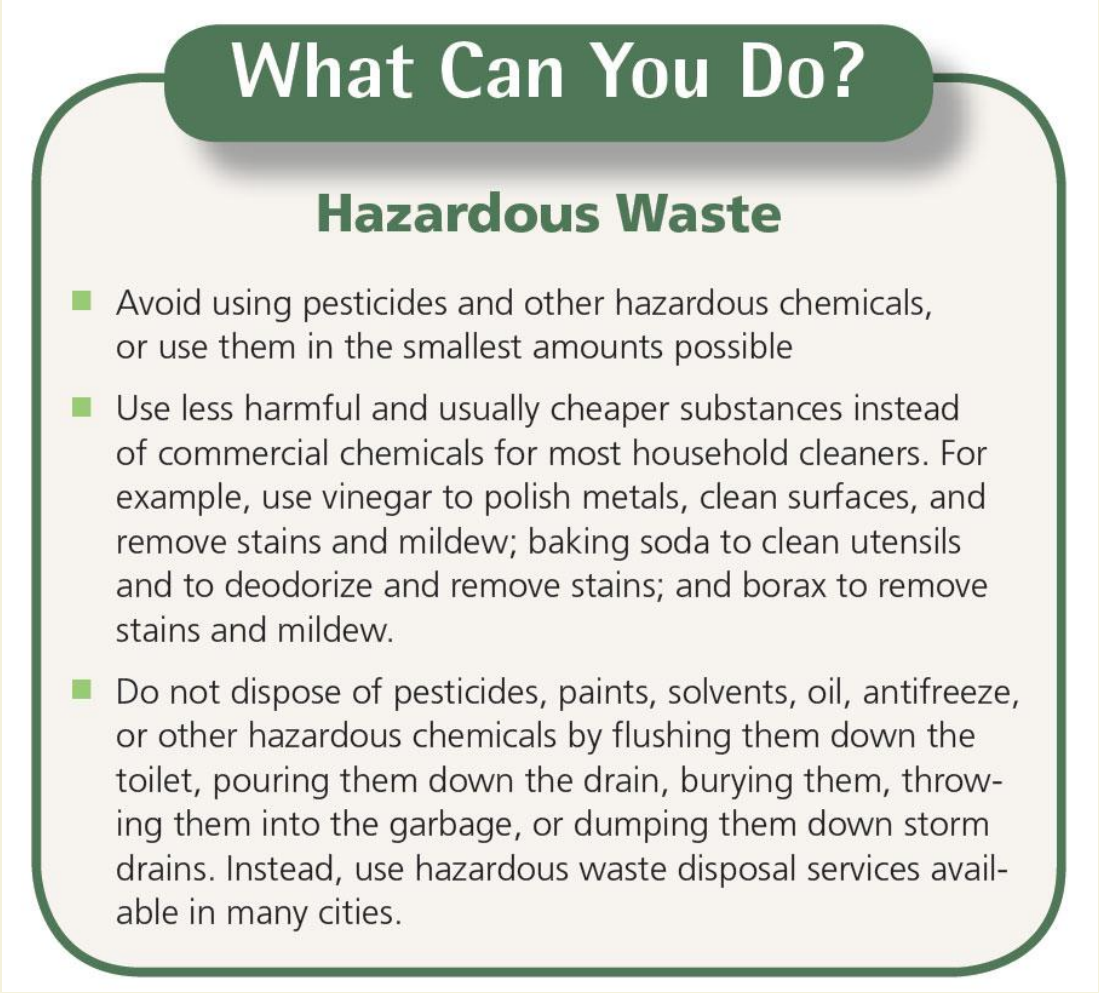
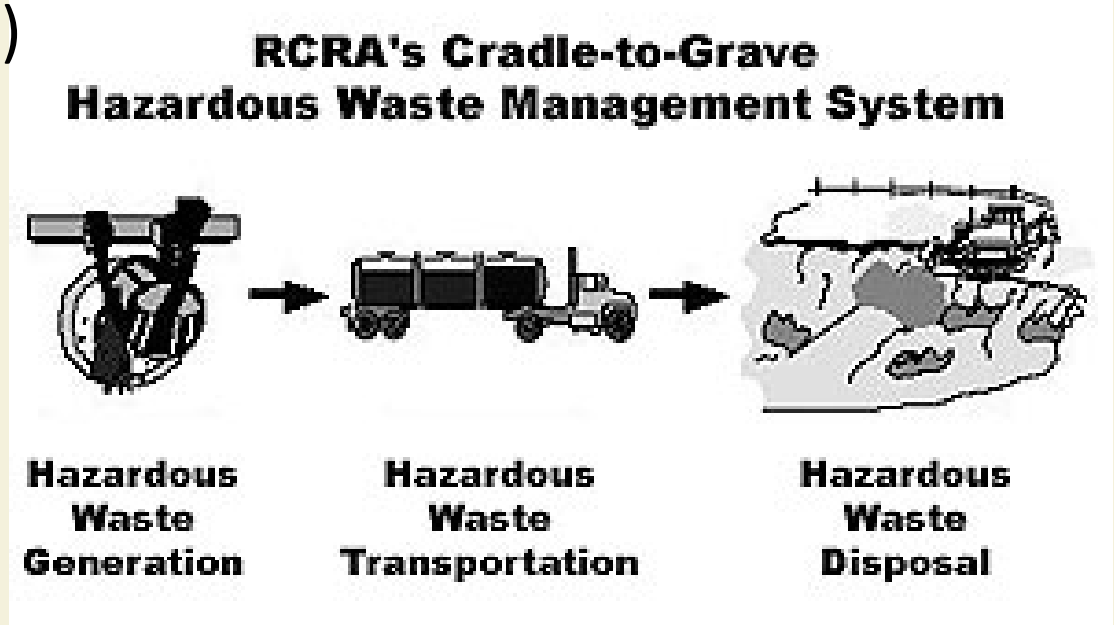


Fig. 21-24, p. 578

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

- 1976: Resource Conservation and Recovery Act (**RCRA**)
  - EPA sets standards and gives permits
  - Cradle to grave- company must track and submit proof to EPA
  - Covers only 5% of hazardous wastes in US (less in dev'ing countries)



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

- 1980: Comprehensive Environmental, Compensation, and Liability Act (**CERCLA**) aka Superfund
  - National Priorities List
    - 2010: 1300 sites – should be 10,000. 340 sites cleaned so far
  - Pace of cleanup has slowed
  - Superfund is broke – Congress wouldn't renew the tax on the polluters after the original law expired in 1995
  - **Taxpayers are paying >$1 billion/year**

http://www.epa.gov/superfund/sites/index.htm

- Laws encouraging the cleanup of brownfields (~500,000 abandoned factories, junkyards, landfills, gas stations, etc.)

Superfund Sites

Leaking Barrels of Toxic Waste at a Superfund Site in the United States

Fig. 21-25, p. 578

21-6 How Can We Make the Transition to a More Sustainable Low-Waste Society?

- ***Concept 21-6*** *Shifting to a low-waste society requires individuals and businesses to reduce resource use and to reuse and recycle wastes at local, national, and global levels.*

Grassroots Action Has Led to Better Solid and Hazardous Waste Management

- “Not in my backyard”
- Produce less waste
  - “Not in anyone’s backyard”
  - “Not on planet Earth”

Providing Environmental Justice for Everyone Is an Important Goal

- **Environmental Justice**
  - Everyone is entitled to protection from environmental hazards

- Which communities in the U.S. have the largest share of hazardous waste dumps?

- Environmental discrimination

International Treaties Have Reduced Hazardous Waste (1)

- **Basel Convention**
  - 1992: in effect
  - 1995 amendment: bans all transfers of hazardous wastes from industrialized countries to less-developed countries
  - 2009: Ratified by 195 countries, but not the United States

International Treaties Have Reduced Hazardous Waste (2)

- 2000: Delegates from 122 countries completed a global treaty – **Stockholm Convention**
  - Control 12 persistent organic pollutants (POPs)
  - “Dirty dozen”
  - DDT, PCBs, dioxins
  - Everyone on earth has POPs in blood

- 2000: Swedish Parliament law
  - By 2020 ban all chemicals that are persistent and can accumulate in living tissue
  - Guilty until proven safe!!

We Can Make the Transition to Low-Waste Societies

- Norway, Austria, and the Netherlands
  - Committed to reduce resource waste by 75%

- East Hampton, NY, U.S.
  - Reduced solid waste by 85%
  - Zero waste movement

- Follow guidelines to prevent pollution and reduce waste

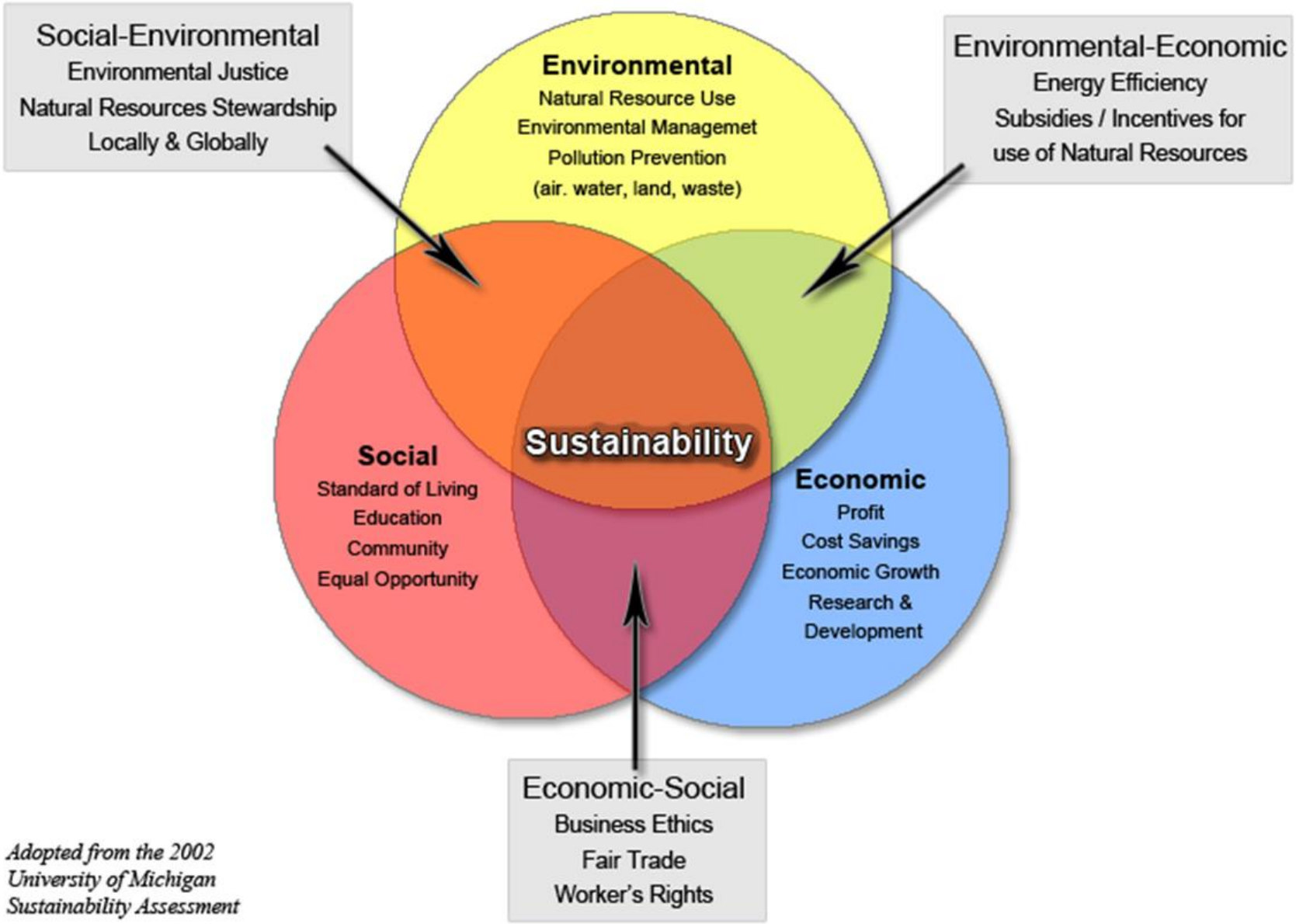
Case Study: Industrial Ecosystems: Copying Nature

- **Biomimicry**: using natural principles to solve human problems

- Nature: wastes of one organism are nutrients for another; apply to industry
  - Ecoindustrial parks

- Two major steps of biomimicry
  1. Observe how natural systems respond
  2. Apply to human industrial systems

The Three Spheres of Sustainability



Adopted from the 2002 University of Michigan Sustainability Assessment

When You Throw
it Away

Think.

There is no Away

Three Big Ideas

1. The order of priorities for dealing with solid waste should be to produce less of it, reuse and recycle as much of it as possible, and safely dispose of what is left.
2. The order of priorities for dealing with hazardous waste should be to produce less of it, reuse or recycle it, convert it to less hazardous material, and safely store what is left.
3. We need to view solid wastes as wasted resources and hazardous wastes as materials that we should not be producing in the first place.