Unit #5

Waste Management and Urbanization

Essential Questions

- What is solid waste and how much do we produce?
- How can we produce less solid waste?
- What are the advantages and disadvantages of reusing recycled materials?
- What are the advantages and disadvantages of burning or burying solid waste?
- What is hazardous waste and how can we deal with it?
- What can we do to reduce exposure to lead and mercury?
- How can we make the transition to a more sustainable low-waste society?

Essential Questions

- How is polluted water treated?
- How is the world's population distributed between rural and urban areas, and what factors determine how urban areas develop?
- What are the major resource and environmental problems of urban areas?
- How do transportation systems shape urban areas and growth, and what are the advantages and disadvantages of various forms of transportation?
- What methods are used for planning and controlling urban growth?
- How can cities be made more sustainable and more desirable places to live?

Core Case Study: Love Canal — There Is No "Away"

- Between 1842-1953, Hooker Chemical sealed multiple chemical wastes into steel drums and dumped them into an old canal excavation (Love Canal).
- In 1953, the canal was filled and sold to Niagara Falls school board for $1.
- The company inserted a disclaimer denying liability for the wastes.

Core Case Study: Love Canal — There Is No "Away"

- In 1957, Hooker Chemical warned the school not to disturb the site because of the toxic waste.
  - In 1959 an elementary school, playing fields and homes were built disrupting the clay cap covering the wastes.
  - In 1976, residents complained of chemical smells and chemical burns from the site.

Core Case Study: Love Canal — There Is No "Away"

- President Jimmy Carter declared Love Canal a federal disaster area.
  - The area was abandoned in 1980 (left).

Core Case Study: Love Canal — There Is No "Away"

- It still is a controversy as to how much the chemicals at Love Canal injured or caused disease to the residents.
- Love Canal sparked creation of the Superfund law, which forced polluters to pay for cleaning up abandoned toxic waste dumps.

WASTING RESOURCES

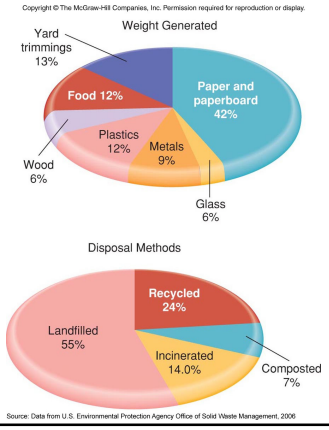
- ***Solid waste***: any unwanted or discarded material we produce that is not a liquid or gas.
  - ***Municipal solid waste (MSW)***: produce directly from homes.
  - ***Industrial solid waste***: produced indirectly by industries that supply people with goods and services.
- ***Hazardous (toxic) waste***: threatens human health or the environment because it is toxic, chemically active, corrosive or flammable.

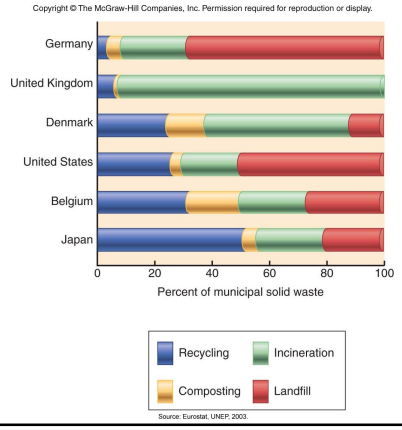
WASTING RESOURCES

- Solid wastes polluting a river in Jakarta, Indonesia. The man in the boat is looking for items to salvage or sell.

WASTING RESOURCES

- The United States produces about a third of the world's solid waste and buries more than half of it in landfills.
  - About 98.5% is industrial solid waste.
  - The remaining 1.5% is MSW.
    - About 55% of U.S. MSW is dumped into landfills, 30% is recycled or composted, and 15% is burned in incinerators.

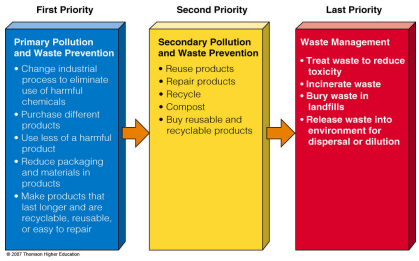




Electronic Waste: A Growing Problem

- E-waste consists of toxic and hazardous waste such as PVC, lead, mercury, and cadmium.
- The U.S. produces almost half of the world's e-waste but only recycles about 10% of it.

INTEGRATED WASTE MANAGEMENT



- We can manage the solid wastes we produce and reduce or prevent their production.

Solutions: Reducing Solid Waste

- ***Refuse***: to buy items that we really don't need.
- ***Reduce***: consume less and live a simpler and less stressful life by practicing simplicity.
- ***Reuse***: rely more on items that can be used over and over.
- ***Repurpose***: use something for another purpose instead of throwing it away.
- ***Recycle***: paper, glass, cans, plastics…and buy items made from recycled materials.

What Can You Do?

Solid Waste

- **Follow the five Rs of resource use: Refuse, Reduce, Reuse, Repurpose, and Recycle.**
- **Ask yourself whether you really need a particular item.**
- **Rent, borrow, or barter goods and services when you can.**
- **Buy things that are reusable, recyclable, or compostable, and be sure to reuse, recycle, and compost them.**
- **Do not use throwaway paper and plastic plates, cups and eating utensils, and other disposable items when reusable or refillable versions are available.**
- **Refill and reuse a bottled water container with tap water.**
- **Use e-mail in place of conventional paper mail.**
- **Read newspapers and magazines online.**
- **Buy products in concentrated form whenever possible.**

REUSE

- Reusing products is an important way to reduce resource use, waste, and pollution in developed countries.
- Reusing can be hazardous in developing countries for poor who scavenge in open dumps.
  - They can be exposed to toxins or infectious diseases.

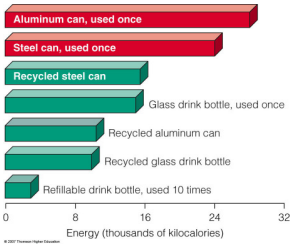
How People Reuse Materials

- Children looking for materials to sell in an open dump near Manila in the Philippines.

Case Study: Using Refillable Containers

- Refilling and reusing containers uses fewer resources and less energy, produces less waste, saves money, and creates jobs.
  - In Denmark and Canada's Price Edward's Island there is a ban on all beverage containers that cannot be reused.
  - In Finland 95% of soft drink and alcoholic beverages are refillable (Germany 75%).

REUSE



- Reducing resource waste: energy consumption for different types of 350-ml (12-oz) beverage containers.

Solutions: Other Ways to Reuse Things

- We can use reusable shopping bags, food containers, and shipping pallets, and borrow tools from tool libraries.
  - Many countries in Europe and Asia charge shoppers for plastic bags.

What Can You Do?

Reuse

- **Buy beverages in refillable glass containers instead of cans or throwaway bottles.**
- **Use reusable plastic or metal lunchboxes.**
- **Carry sandwiches and store food in the refrigerator in reusable containers instead of wrapping them in aluminum foil or plastic wrap**
- **Use rechargeable batteries and recycle them when their useful life is over.**
- **Carry groceries and other items in a reusable basket, a canvas or string bag, or a small cart.**
- **Use reusable sponges and washable cloth napkins, dishtowels, and handkerchiefs instead of throwaway paper ones.**
- **Buy used furniture, computers, cars, and other items.**
- **Give or sell items you no longer use to others.**

RECYCLING

- ***Primary (closed loop) recycling***: materials are turned into new products of the same type.
- ***Secondary recycling***: materials are converted into different products.
  - Used tires shredded and converted into rubberized road surface.
  - Newspapers transformed into cellulose insulation.

RECYCLING

- There is a disagreement over whether to mix urban wastes and send them to centralized resource recovery plants or to sort recyclables for collection and sale to manufacturers as raw materials.
  - To promote separation of wastes, 4,000 communities in the U.S. have implemented ***pay-as-you-throw*** or ***fee-per-bag*** waste collection systems.

RECYCLING

- Composting biodegradable organic waste mimics nature by recycling plant nutrients to the soil.
- Recycling paper has a number of environmental (reduction in pollution and deforestation, less energy expenditure) and economic benefits and is easy to do.

RECYCLING

- Recycling many plastics is chemically and economically difficult.
  - Many plastics are hard to isolate from other wastes.
  - Recovering individual plastic resins does not yield much material.
  - The cost of virgin plastic resins in low than recycled resins due to low fossil fuel costs.
  - There are new technologies that are making plastics biodegradable.

RECYCLING

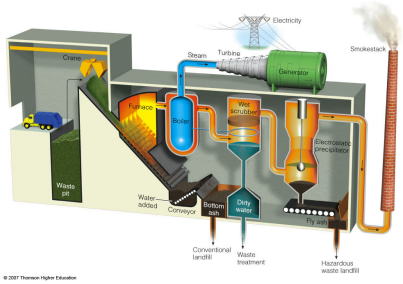
- Reuse and recycling are hindered by prices of goods that do not reflect their harmful environmental impacts, too few government subsidies and tax breaks, and price fluctuations.

Fig. 22-9, p. 529

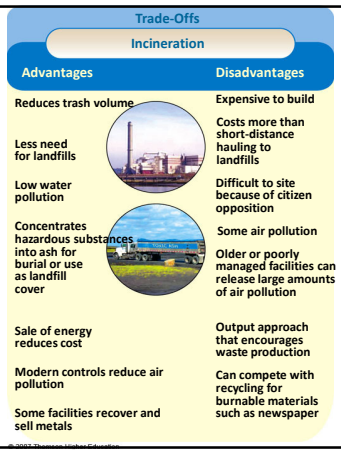
BURNING AND BURYING SOLID WASTE

- Globally, MSW is burned in over 1,000 large ***waste-to-energy incinerators***, which boil water to make steam for heating water, or space, or for production of electricity.
  - Japan and a few European countries incinerate most of their MSW.

Burning Solid Waste

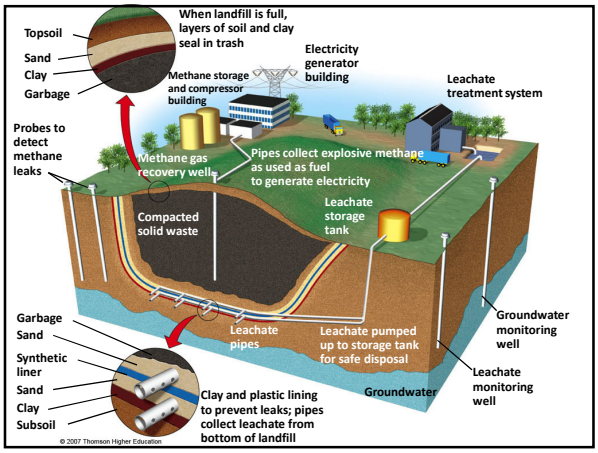


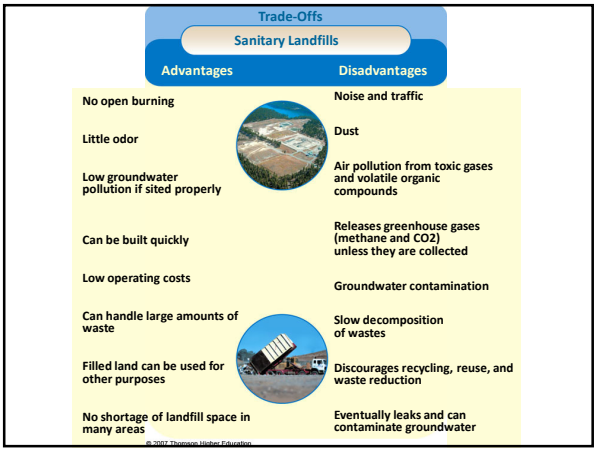
- Waste-to-energy incinerator with pollution controls that burns mixed solid waste.



Burying Solid Waste

- Most of the world's MSW is buried in landfills that eventually are expected to leak toxic liquids into the soil and underlying aquifers.
  - ***Open dumps***: are fields or holes in the ground where garbage is deposited and sometimes covered with soil. Mostly used in developing countries.
  - ***Sanitary landfills***: solid wastes are spread out in thin layers, compacted and covered daily with a fresh layer of clay or plastic foam.





Case Study: What Should We Do with Used Tires?

- We face a dilemma in deciding what to so with hundreds of millions of discarded tires.

HAZARDOUS WASTE

- ***Hazardous waste***: is any discarded solid or liquid material that is toxic, ignitable, corrosive, or reactive enough to explode or release toxic fumes.
  - The two largest classes of hazardous wastes are organic compounds (e.g. pesticides, PCBs, dioxins) and toxic heavy metals (e.g. lead, mercury, arsenic).

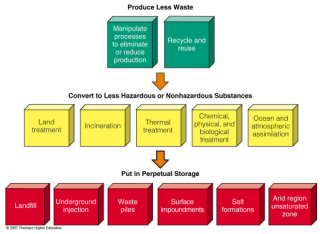
Hazardous Waste Regulations in the United States

- Two major federal laws regulate the management and disposal of hazardous waste in the U.S.:
  - Resource Conservation and Recovery Act (RCRA)
    - Cradle-to-the-grave system to keep track waste.
  - Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
    - Commonly known as Superfund program.

Hazardous Waste Regulations in the United States

- The Superfund law was designed to have polluters pay for cleaning up abandoned hazardous waste sites.
  - Only 70% of the cleanup costs have come from the polluters, the rest comes from a trust fund financed until 1995 by taxes on chemical raw materials and oil.

DEALING WITH HAZARDOUS WASTE



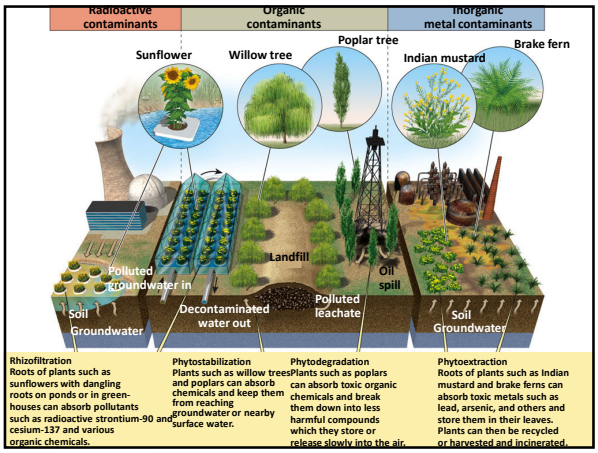
- We can produce less hazardous waste and recycle, reuse, detoxify, burn, and bury what we continue to produce.

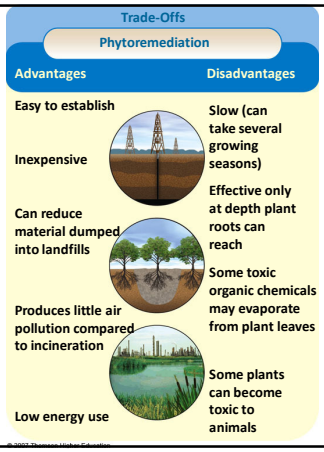
Conversion to Less Hazardous Substances

- ***Physical Methods***: using charcoal or resins to separate out harmful chemicals.
- ***Chemical Methods***: using chemical reactions that can convert hazardous chemicals to less harmful or harmless chemicals.

Conversion to Less Hazardous Substances

- ***Biological Methods***:
  - ***Bioremediation***: bacteria or enzymes help destroy toxic and hazardous waste or convert them to more benign substances.
  - ***Phytoremediation***: involves using natural or genetically engineered plants to absorb, filter and remove contaminants from polluted soil and water.



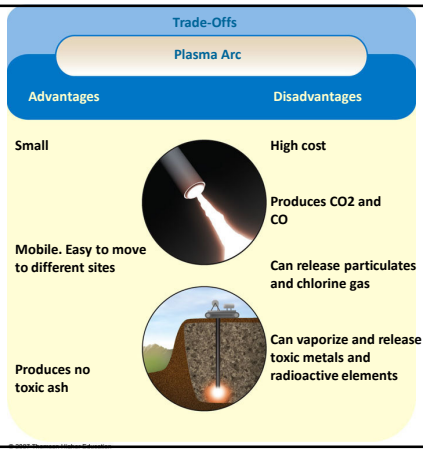


Conversion to Less Hazardous Substances

- ***Incineration***: heating many types of hazardous waste to high temperatures – up to 2000 ℃ – in an incinerator can break them down and convert them to less harmful or harmless chemicals.

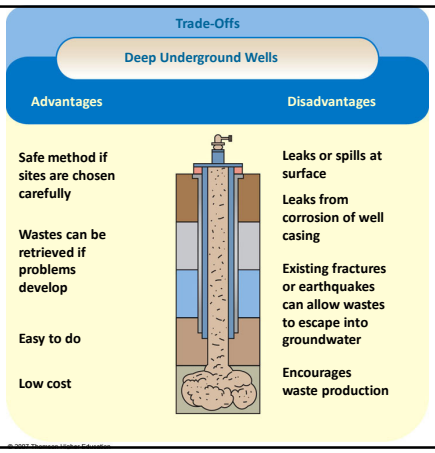
Conversion to Less Hazardous Substances

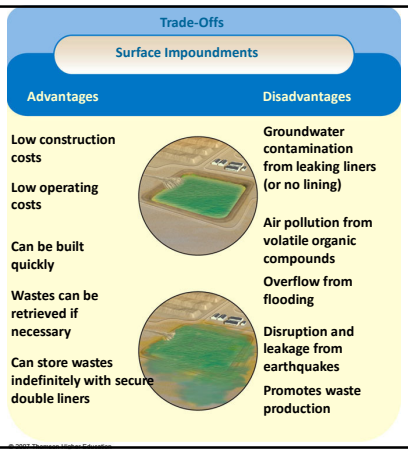
- ***Plasma Torch***: passing electrical current through gas to generate an electric arc and very high temperatures can create plasma.
  - The plasma process can be carried out in a torch which can decompose liquid or solid hazardous organic material.



Long-Term Storage of Hazardous Waste

- Hazardous waste can be disposed of on or underneath the earth's surface, but without proper design and care this can pollute the air and water.
  - ***Deep-well disposal***: liquid hazardous wastes are pumped under pressure into dry porous rock far beneath aquifers.
  - ***Surface impoundments***: excavated depressions such as ponds, pits, or lagoons into which liners are placed and liquid hazardous wastes are stored.

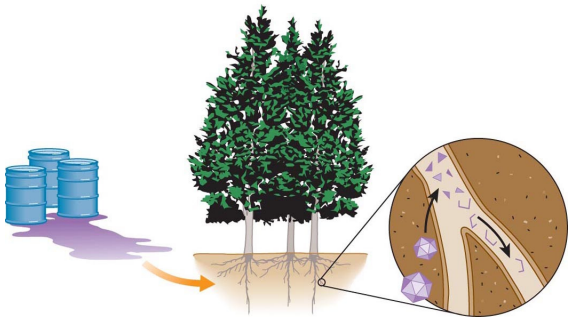




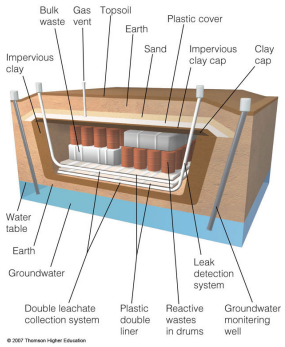
Long-Term Storage of Hazardous Waste

- ***Long-Term Retrievable Storage***: Some highly toxic materials cannot be detoxified or destroyed. Metal drums are used to stored them in areas that can be inspected and retrieved.
- ***Secure Landfills***: Sometimes hazardous waste are put into drums and buried in carefully designed and monitored sites.

Source: Environmental Protection Agency.



Secure Hazardous Waste Landfill



- In the U.S. there are only 23 commercial hazardous waste landfills.

What Can You Do?

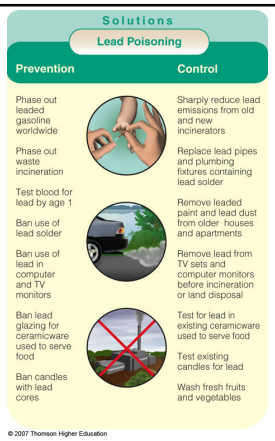
Hazardous Waste

- Use pesticides in the smallest amount possible.
- Use less harmful substances instead of commercial chemicals for most household cleaners. For example use liquid ammonia to clean appliances and windows; vinegar to polish metals, clean surfaces, and remove stains and mildew; baking soda to clean household utensils, deodorize, and remove stains; borax to remove stains and mildew.
- Do not dispose of pesticides, paints, solvents, oil, antifreeze, or other products containing hazardous chemicals by flushing them down the toilet, pouring them down the drain, burying them, throwing them into the garbage, or dumping them down storm drains.

Table 21.1 How Should You Dispose of Household Hazardous Waste?

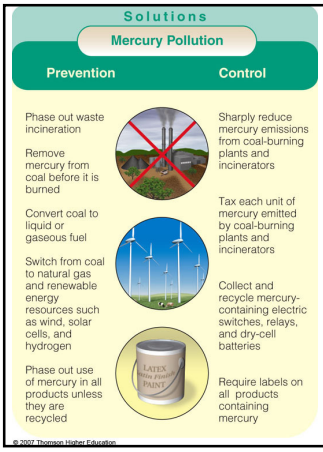
Flush to sewer system (drain or toilet)	Cleaning agents with ammonia or bleach, disinfectants, glass cleaner, toilet cleaner
Put dried solids in household trash	Cosmetics, putty, grout, caulking, empty solvent containers, water-based glue, fertilizer (without weed killer)
Save and deliver to a waste collection center	*Solvents:* cleaning agents (drain cleaner, floor wax-stripper, furniture polish, metal cleaner, oven cleaner), paint thinner and other solvents, glue with solvents, varnish, nail polish remover *Metals:* mercury thermometers, button batteries, NiCad batteries, auto batteries, paints with lead or mercury, fluorescent light bulbs/tubes/ballasts, electronics and appliances *Poisons:* bug spray, pesticides, weed killers, rat poison, insect poison, mothballs *Other chemicals:* antifreeze, gasoline, fuel oil, brake fluid, transmission fluid, paint, rust remover, hairspray, photo chemicals

Source: EPA, 2005.



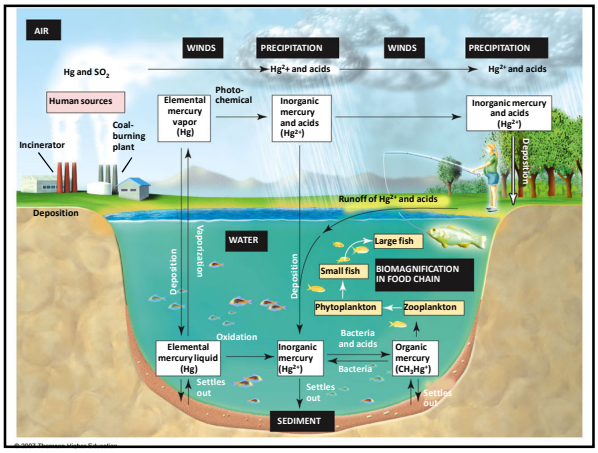
Case Study: Lead

- Lead is especially harmful to children and is still used in leaded gasoline and household paints in about 100 countries.



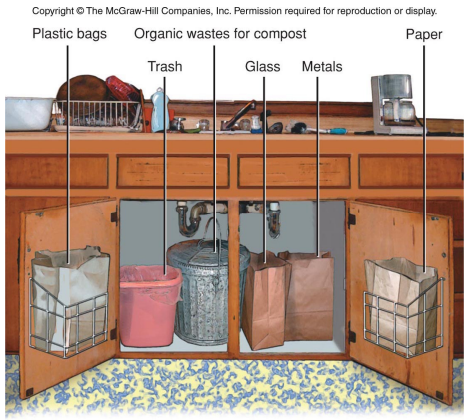
Case Study: Mercury

- Mercury is released into the environment mostly by burning coal and incinerating wastes and can build to high levels in some types of fish.



ACHIEVING A LOW-WASTE SOCIETY

- In the U.S., citizens have kept large numbers of incinerators, landfills, and hazardous waste treatment plants from being built in their local areas.
- Environmental justice means that everyone is entitled to protection from environmental hazards without discrimination.



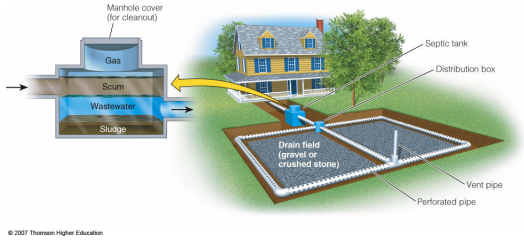
Global Outlook: International Action to Reduce Hazardous Waste

- An international treaty calls for phasing out the use of harmful persistent organic pollutants (POPs).
  - POPs are insoluble in water and soluble in fat.
  - Nearly every person on earth has detectable levels of POPs in their blood.
  - The U.S has not ratified this treaty.

Making the Transition to a Low-Waste Society: A New Vision

- Everything is connected.
- There is no "away" for the wastes we produce.
- Dilution is not always the solution to pollution.
- The best and cheapest way to deal with wastes are reduction and pollution prevention.

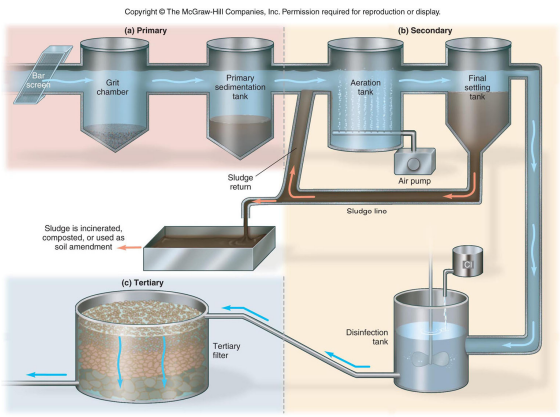
Reducing Water Pollution through Sewage Treatment



- Septic tanks and various levels of sewage treatment can reduce point-source water pollution.

Reducing Water Pollution through Sewage Treatment

- Raw sewage reaching a municipal sewage treatment plant typically undergoes:
  - ***Primary sewage treatment***: a physical process that uses screens and a grit tank to remove large floating objects and allows settling.
  - ***Secondary sewage treatment***: a biological process in which aerobic bacteria remove as much as 90% of dissolved and biodegradable, oxygen demanding organic wastes.

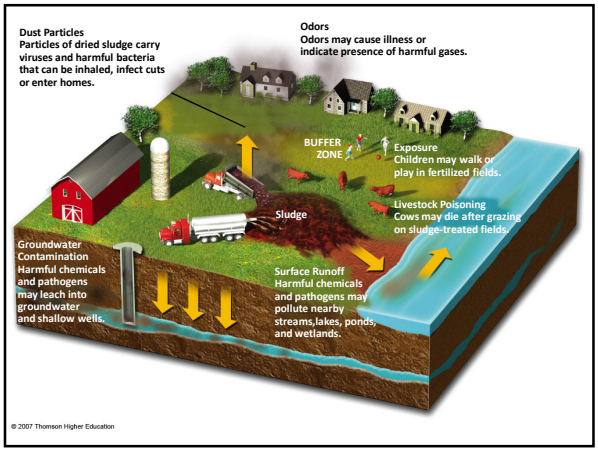


Reducing Water Pollution through Sewage Treatment

- Advanced or tertiary sewage treatment:
  - Uses series of chemical and physical processes to remove specific pollutants left (especially nitrates and phosphates).
- Water is chlorinated to remove coloration and to kill disease-carrying bacteria and some viruses (disinfect).

Reducing Water Pollution through Sewage Treatment

- Sewage sludge can be used as a soil conditioner but this can cause health problems if it contains infectious bacteria and toxic chemicals.
- Preventing toxic chemicals from reaching sewage treatment plants would eliminate such chemicals from the sludge and water discharged from such plants.



Reducing Water Pollution through Sewage Treatment

- Natural and artificial wetlands and other ecological systems can be used to treat sewage.
  - California created a 65 hectare wetland near Humboldt Bay that acts as a natural wastewater treatment plant for the town of 16,000 people.
    - The project cost less than half of the estimated price of a conventional treatment plant.

Reducing Water Pollution through Sewage Treatment

- Water pollution laws have significantly improved water quality in many U.S. streams and lakes but there is a long way to go.
- Some want to strengthen the U.S. Clean Water Act (CWA) to prevent rather than focusing on end-of-the-pipe removal.
- Many farmers and developers see the CWA as limiting their rights as property owners to fill in wetlands.

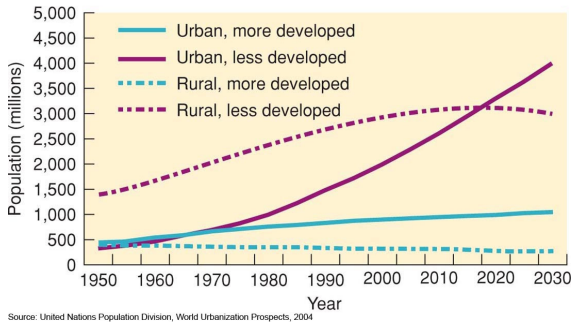
Table 22.1 Urban Share of Total Population (Percentage)

	1950	2000	2030*
Africa	18.4	40.6	57.0
Asia	19.3	43.8	59.3
Europe	56.0	75.0	81.5
Latin America	40.0	70.3	79.7
North America	63.9	77.4	84.5
Oceania	32.0	49.5	60.7
World	38.3	59.4	70.5

*Projected

Source: United Nations Population Division, 2004.

Figure 22.03

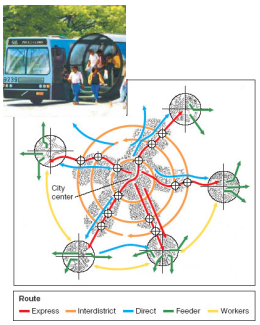


Source: United Nations Population Division, World Urbanization Prospects, 2004

Core Case Study: The Ecocity Concept in Curitiba, Brazil

- 70% of Curitiba's 2 million people use the bus system.
- Only high-rise apartments are allowed near bus routes and devote the bottom 2 floors to stores.
- Bike paths run through the city.
- Cars are banned from 49 blocks of the city's downtown.

Core Case Study: The Ecocity Concept in Curitiba, Brazil



- This bus system moves large numbers of passengers based on its infrastructure:
  - Express lanes for buses only.
  - Double and triple length buses.
  - Extra-wide doors for easy boarding.

Table 22.2 The World's Largest Urban Areas (Populations in Millions)

1900		2015**	
London, England	6.6	Tokyo, Japan	31.0
New York, USA	4.2	New York, USA	29.9
Paris, France	3.3	Mexico City	21.0
Berlin, Germany	2.4	Seoul, Korea	19.8
Chicago, USA	1.7	São Paulo, Brazil	18.5
Vienna, Austria	1.6	Osaka, Japan	17.6
Tokyo, Japan	1.5	Jakarta, Indonesia	17.4
St. Petersburg, Russia	1.4	Delhi, India	16.7
Philadelphia, USA	1.4	Los Angeles, USA	16.6
Manchester, England	1.3	Beijing, China	16.0
Birmingham, England	1.2	Cairo, Egypt	15.5
Moscow, Russia	1.1	Manila, Philippines	13.5
Peking, China*	1.1	Buenos Aires, Brazil	12.9

*Now spelled Beijing.

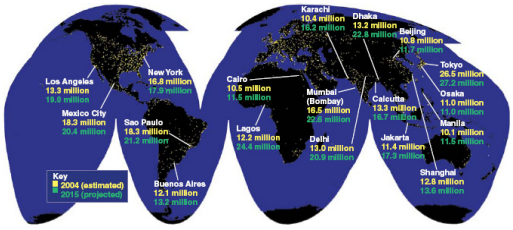
**Projected.

Source: T. Chandler, Three Thousand Years of Urban Growth, 1974, Academic Press and World Gazetter, 2003.

URBANIZATION AND URBAN GROWTH

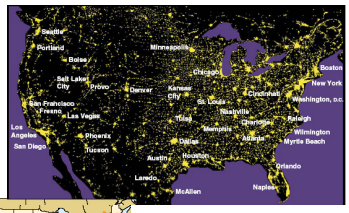
- People move to cities because "push" factors force them out of rural areas and "pull" factors give them the hope of finding jobs and a better life in the city.
- Urban populations are growing rapidly and many cities in developing countries have become centers of poverty.

Major Urban Areas of the World

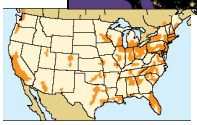


- Satellite images of the earth at night showing city lights. Currently, 49% of the world's population live in urban areas (2% of earth's land area).

Case Study: Urbanization in the U.S.



- 8 of 10 Americans live in Urban areas.

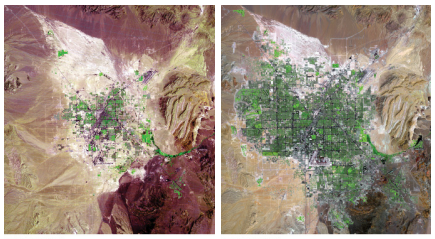


- About 48% of Americans live in consolidated metropolitan areas (bottom map).

Urban Sprawl

- When land is available and affordable, urban areas tend to sprawl outward because:
  - Federal government loan guarantees stimulated the development of suburbs.
  - Low-cost gasoline and government funding of highways encourages automobile use.
  - Tax-laws encourage home ownership.
  - Most zoning laws separate residential and commercial use of land.
  - Many urban areas lack proper planning.

Urban Sprawl



- Urban sprawl in and around Las Vegas, Nevada between 1973 and 2000.

Urban Sprawl

Bowash (Boston to Washington)

- As they grow and sprawl outward, urban areas merge to form megalopolis.
  - Bowash runs from Boston, Massachusetts to Washington, D.C.

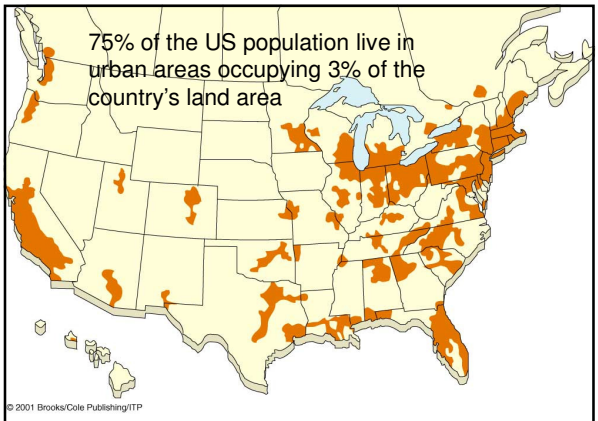


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Table 22.3 Characteristics of Urban Sprawl

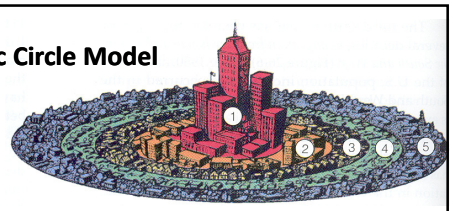
1. Unlimited outward extension.
2. Low-density residential and commercial development.
3. Leapfrog development that consumes farmland and natural areas.
4. Fragmentation of power among many small units of government.
5. Dominance of freeways and private automobiles.
6. No centralized planning or control of land uses.
7. Widespread strip malls and "big-box" shopping centers.
8. Great fiscal disparities among localities.
9. Reliance on deteriorating older neighborhoods for low-income housing.
10. Decaying city centers as new development occurs in previously rural areas.

Source: Excerpt from a speech by Anthony Downs at the CTS Transportation Research Conference, as appeared on Website by Planners Web, Burlington, VT, 2001.

Major Spatial Patterns

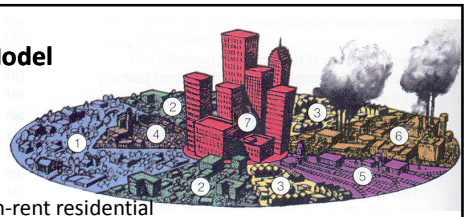
- *Concentric Circle City* such as New York
- *Sector City* is the large urban area extending from San Frdancisco to San Jose, CA
- *Multiple Nuclei City* is Los Angeles
- *Megalopolis* is when separate cities join such as the Bowash

Concentric Circle Model



1. Central business district (CBD)
2. Deteriorating transition zone
3. Worker's homes
4. Middle-class suburbs
5. Commuter's zone

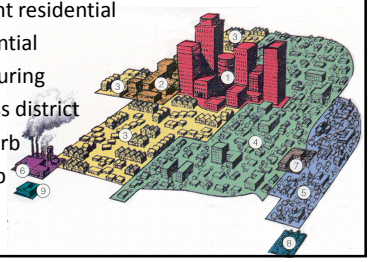
Sector Model

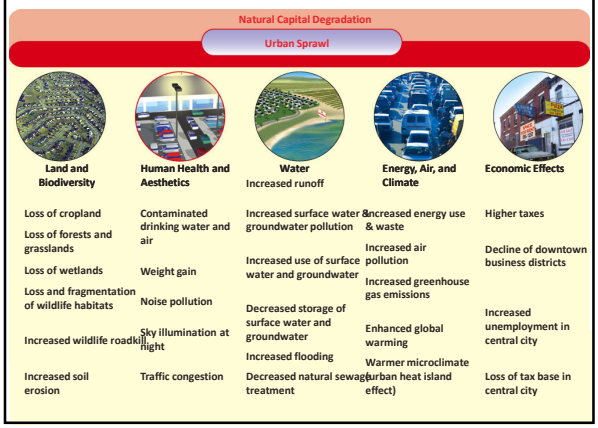


1. High-rent residential
2. Intermediate-rent residential
3. Low-rent residential
4. Education and recreation
5. Transportation
6. Industrial
7. Core (CBD)

Multiple-Nuclei Model

1. CBD
2. Wholesale, light manufacturing
3. Low-rent residential
4. Intermediate-rent residential
5. High-rent residential
6. Heavy manufacturing
7. Outlying business district
8. Residential Suburb
9. Industrial Suburb





URBAN RESOURCE AND ENVIRONMENTAL PROBLEMS

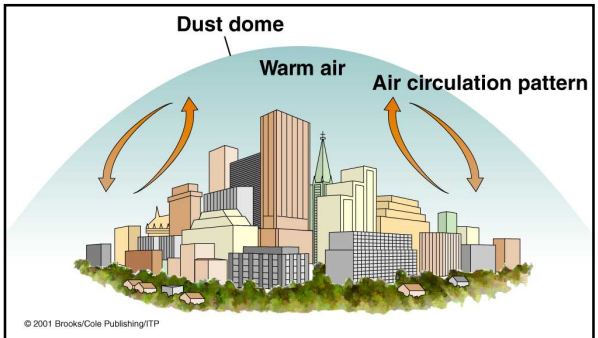
- Urban areas can offer more job opportunities and better education and health, and can help protect biodiversity by concentrating people.

URBAN RESOURCE AND ENVIRONMENTAL PROBLEMS

- Cities are rarely self-sustaining, can threaten biodiversity, lack trees, concentrate pollutants and noise, spread infectious diseases, and are centers of poverty crime, and terrorism.

URBAN RESOURCE AND ENVIRONMENTAL PROBLEMS

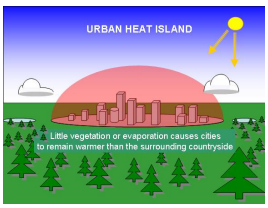
- Urban areas rarely are sustainable systems.



•The enormous amount of heat generated creates an urban heat island

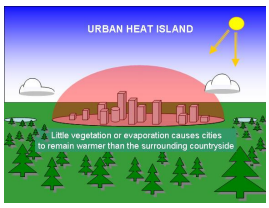
•Additional heat changes climate of surrounding area

Urban Heat Islands



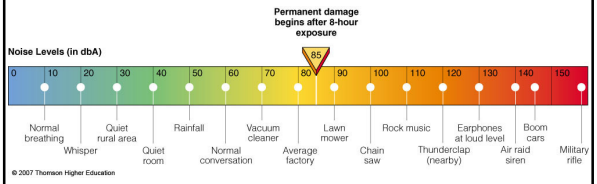
- Urban Heat Island refers to the tendency for a city to remain warmer than its surroundings.
  - Caused by the lack of vegetation and soil moisture, which would normally use the absorbed sunlight to evaporate water as part of photosynthesis (called "evapotranspiration")

Urban Heat Islands



- With little or no water to evaporate, the sunlight's energy goes into raising the temperature of manmade surfaces and the air in contact with them
- A dome of warm air forms over the city as convection transports heat from the surface to higher in the atmosphere
- After the sun sets, temperatures remain elevated above the vegetated areas around the city, so the heat island effect persists into the night

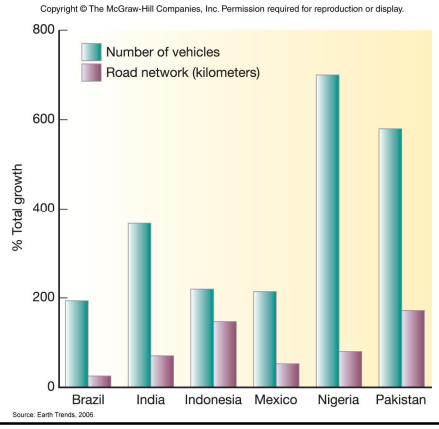
URBAN RESOURCE AND ENVIRONMENTAL PROBLEMS



- ***Noise levels*** of some common sounds. Prolonged exposure to lower noise levels and occasional loud sounds can greatly increase internal stress.

URBAN RESOURCE AND ENVIRONMENTAL PROBLEMS

- Extreme poverty forces hundreds of millions of people to live in slums and shantytowns where adequate water supplies, sewage disposal, and other services do not exist.



TRANSPORTATION AND URBAN DEVELOPMENT

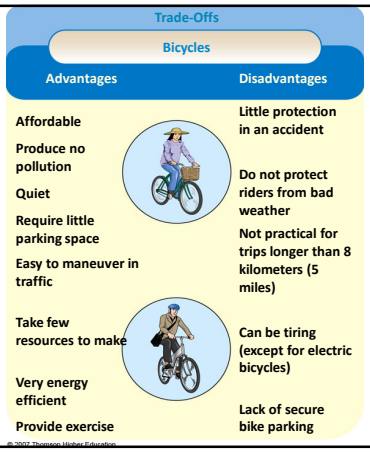
- Land availability determines whether a city must grow vertically or spread out horizontally and whether it relies mostly on mass transit or the automobile.
  - If Americans doubled their use of mass transit from 5% to 10%, this would reduce U.S. dependence on oil by 40%.

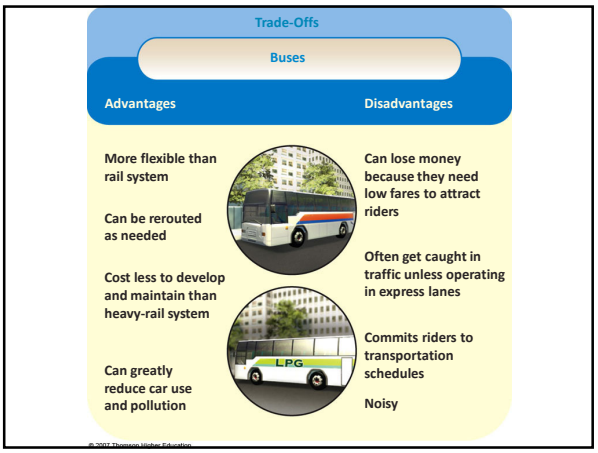
TRANSPORTATION AND URBAN DEVELOPMENT

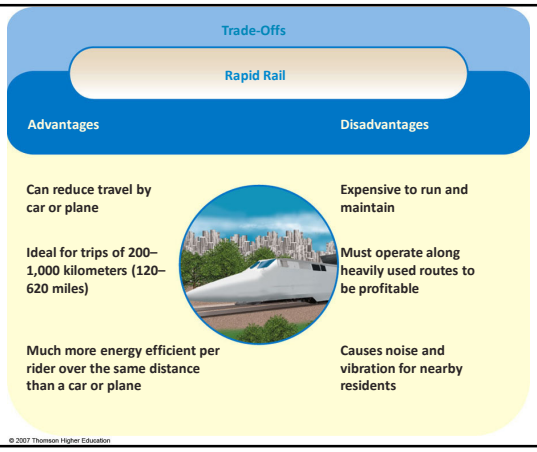
- Motor vehicles provide personal benefits and promote economic growth, but also kill and injure many people, pollute the air, promote urban sprawl, and result in traffic jams.
- Although it would not be politically popular, we could reduce reliance on automobiles by having users pay for their harmful effects.

Solutions: Redesigning Urban Transport

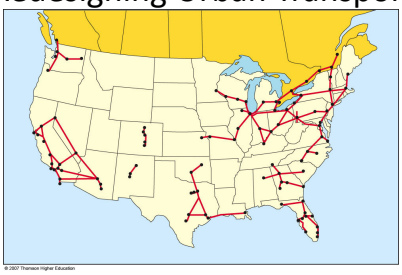
- Alternatives include walking, bicycling, and taking subways, trains, and buses.







Solutions: Redesigning Urban Transport



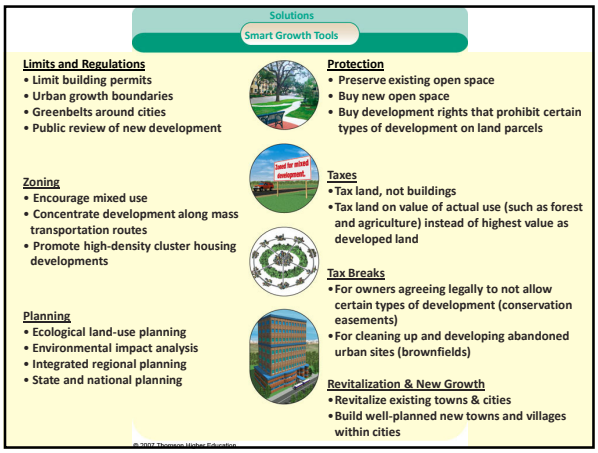
- Potential routes for high-speed bullet trains in the U.S and parts of Canada.

Case Study: Destroying a Great Mass Transit System in the U.S.

- In the early 1900s, the U.S. had one of the world's best street car systems.
  - It was bought and destroyed by companies to sell cars and buses.
  - At the same time, National City Lines worked to convert electric-powered commuter locomotives to diesel-powered ones.

URBAN LAND-USE PLANNING AND CONTROL

- Most land-use planning in the U.S leads to poorly controlled urban sprawl and fund this often environmentally destructive process with property taxes.
- Smart growth can help control growth patterns discourage urban sprawl, reduce car dependence, and protect ecologically sensitive areas.



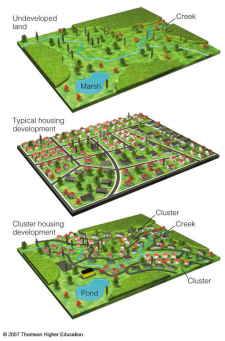
Case Study: Land-Use Planning in Oregon

- Oregon has a comprehensive land-use planning process:
  - Permanently zone all rural land as forest, agriculture, or urban land.
  - Draw an urban growth line around each community.
  - Place control over land-use planning in State hands.

MAKING URBAN AREAS MORE SUSTAINABLE AND DESIREABLE PLACES TO LIVE

- There is a growing movement to create mixed-use villages and neighborhoods within urban areas where people can live, work and shop close to their homes.

Cluster Development



- High density housing units are concentrated on one portion of a parcel with the rest of the land used for commonly shared open space.

The Ecocity Concept

- An ecocity allows people to walk, bike, or take mass transit for most of their travel, and it recycles and reuses most of its wastes, grows much of its own food, and protects biodiversity by preserving surrounding land.

The Ecocity Concept

- Principles of sustainability:
  - Build cities for people not cars.
  - Use renewable energy resources.
  - Use solar-power living machines and wetlands for waste water treatment.
  - Depend largely on recycled water.
  - Use energy and matter efficiently.
  - Prevent pollution and reduce waste.
  - Reuse and recycle at least 60% of municipal solid waste.

The Ecocity Concept

- Protect biodiversity by preserving, protecting, and restoring surrounding natural areas.
- Promote urban gardens and farmers markets.
- Build communities that promote cultural and economic diversity.
- Use zoning and other tools to keep the human population and environmentally sustainable levels.