

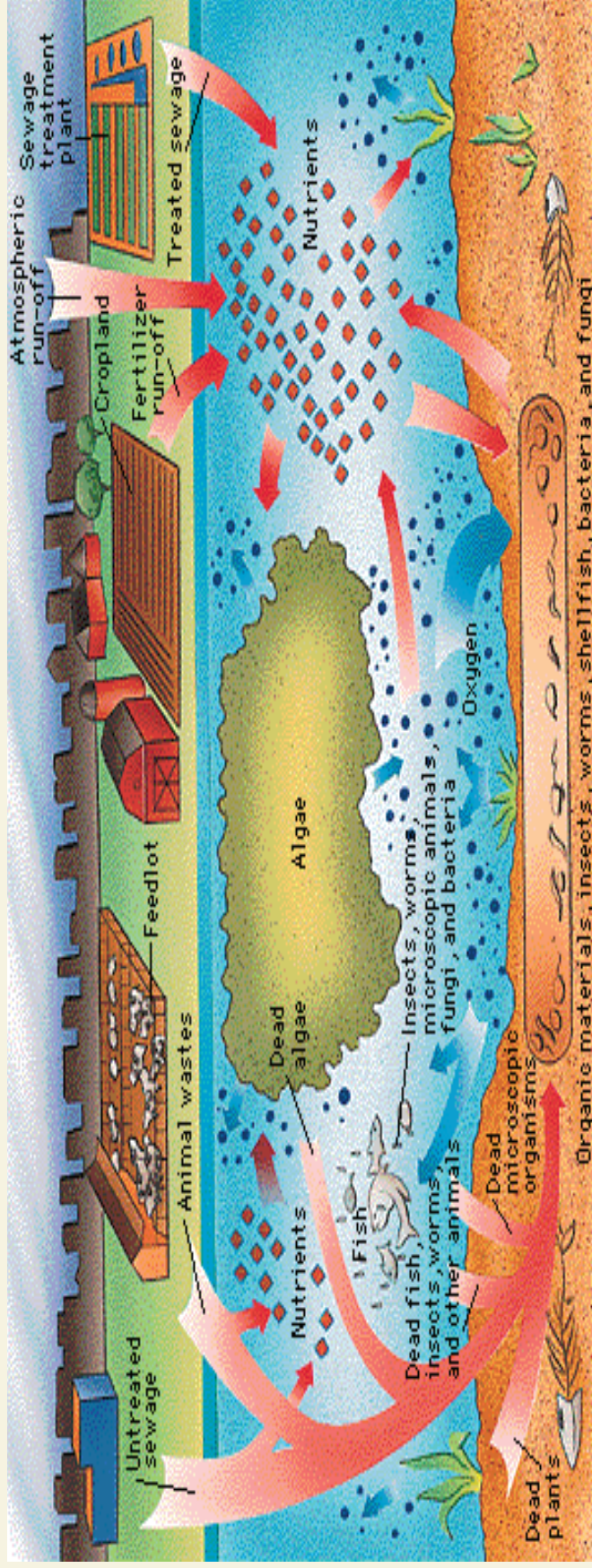
# 20-1 What Are the Causes and Effects of Water Pollution?

- **Concept 20-1A** *Water pollution causes illness and death in humans and other species, and disrupts ecosystems.*
- **Concept 20-1B** *The chief sources of water pollution are agricultural activities, industrial facilities, and mining, but growth in population and resource use make it increasingly worse.*

# Water Pollution

## Water pollution

- Change in water quality that can harm organisms or make water unfit for human uses
- Contamination with chemicals
- Excessive heat



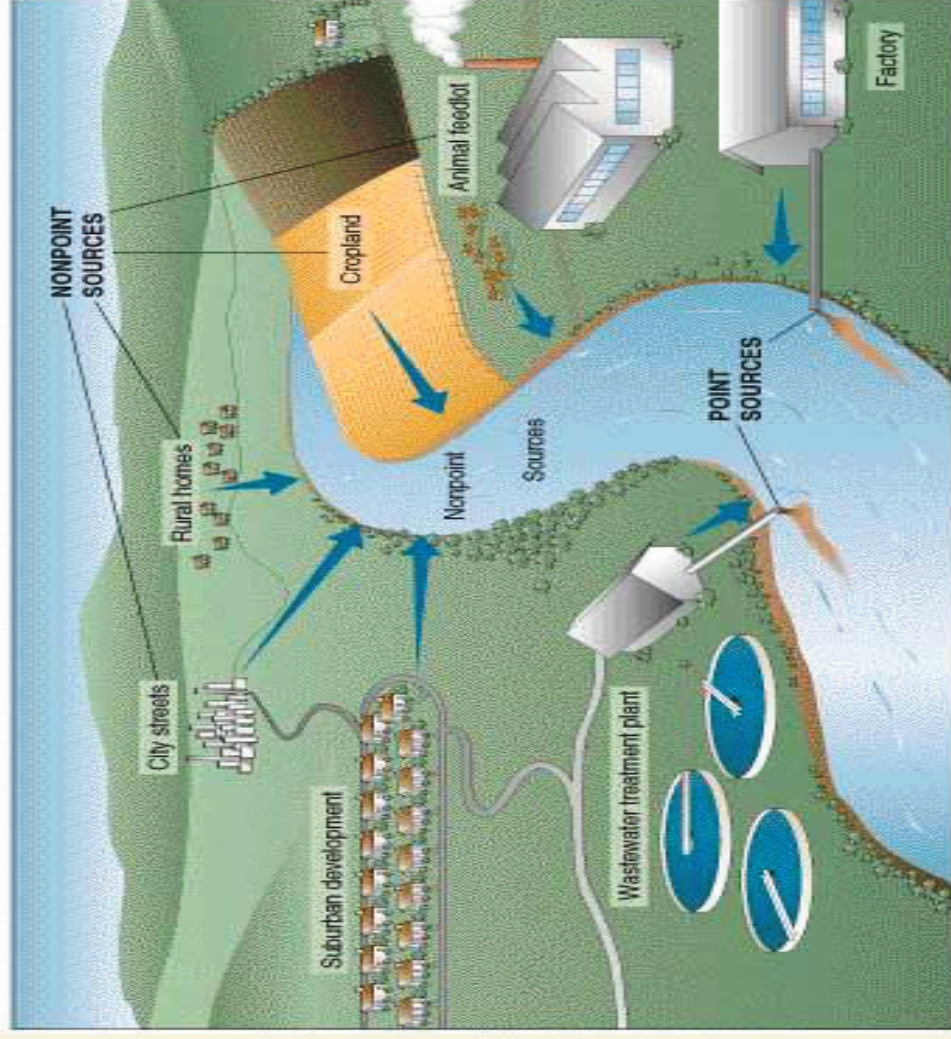
# Water Pollution: Point and Nonpoint Sources

## Nonpoint sources

- Broad, diffuse areas
- Difficult to identify and control
- Expensive to clean up
- Examples

## Point sources

- Located at specific places
- Easy to identify, monitor, and regulate
- Examples





# Leading Causes of Water Pollution

1. Agriculture activities
  - Sediment eroded from the lands
  - Fertilizers and pesticides
  - Bacteria from livestock and food processing wastes
2. Industrial facilities
  - Release inorganic & organic chemicals
  - EX: coal ash (waste from burning coal) – stored in ponds (leak) & dumped into lakes & rivers
3. Mining
  - Surface mining disturbs the land – creates soil erosion & runoff of toxics chemicals



# Point Source of Polluted Water in Gargas, France



Fig. 20-3, p. 530

# Nonpoint Sediment from Unprotected Farmland Flows into Streams



Fig. 20-4, p. 530



# Lake Polluted with Mining Wastes



Fig. 20-5, p. 531



# Plastic Wastes in Mountain Lake



Fig. 20-6, p. 531

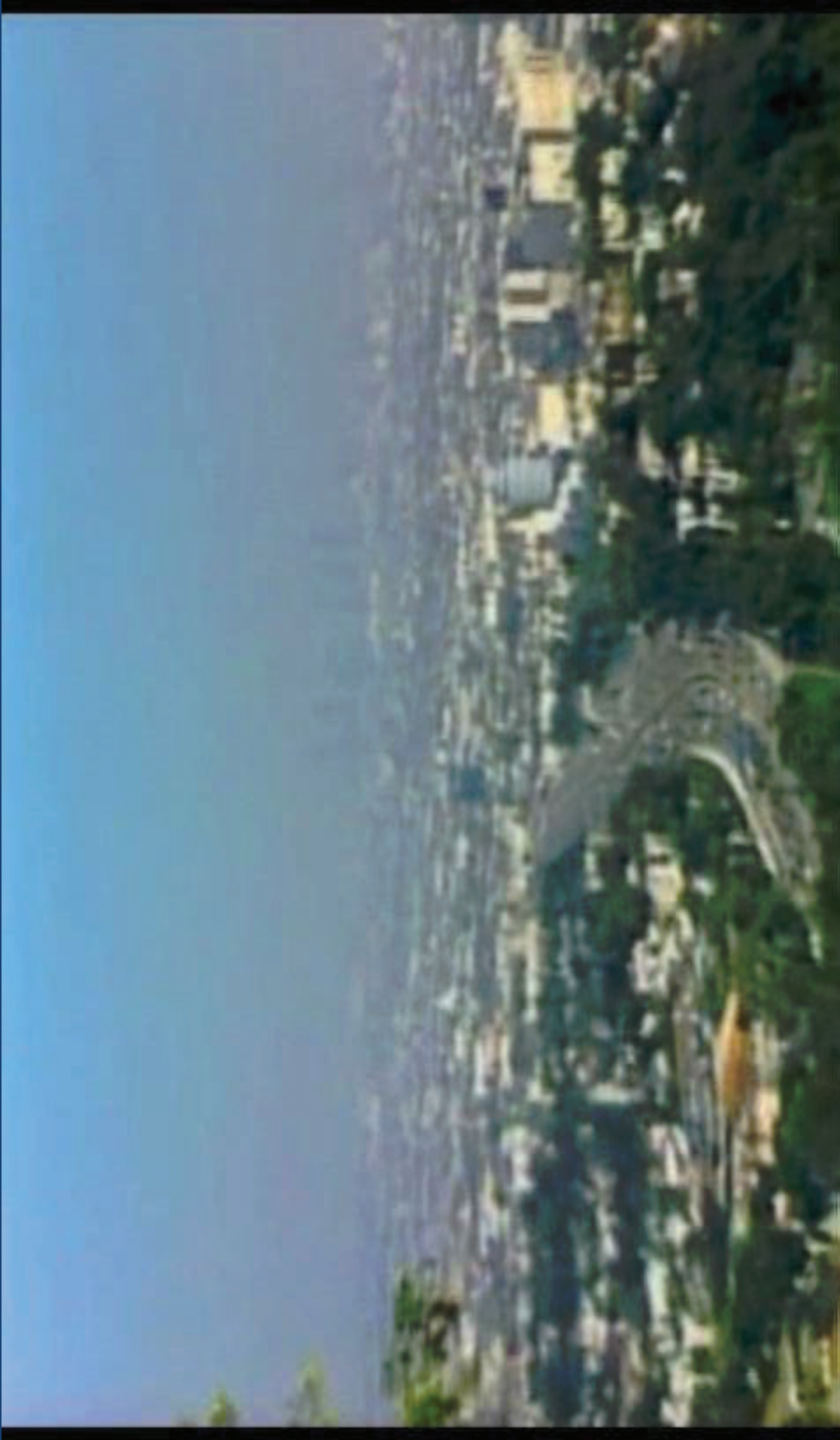
# Major Water Pollutants Have Harmful Effects

- Infectious disease organisms: contaminated drinking water
- The World Health Organization (WHO)
  - 1.6 million people die every year, mostly under the age of 5





# FILM: WATER CONTAMINATION





# Major Water Pollutants and Their Sources

**Table 20-1** Major Water Pollutants and Their Sources

Type/Effects	Examples	Major Sources
Infectious agents (pathogens) Cause diseases	Bacteria, viruses, protozoa, parasites	Human and animal wastes
Oxygen-demanding wastes Deplete dissolved oxygen needed by aquatic species	Biodegradable animal wastes and plant debris	Sewage, animal feedlots, food-processing facilities, paper mills
Plant nutrients Cause excessive growth of algae and other species	Nitrates ( $\text{NO}_3^-$ ) and phosphates ( $\text{PO}_4^{3-}$ )	Sewage, animal wastes, inorganic fertilizers
Organic chemicals Add toxins to aquatic systems	Oil, gasoline, plastics, pesticides, fertilizers, cleaning solvents	Industry, farms, households, mining sites, runoff from streets and parking lots
Inorganic chemicals Add toxins to aquatic systems	Acids, bases, salts, metal compounds	Industry, households, mining sites, runoff from streets and parking lots
Sediments Disrupt photosynthesis, food webs, other processes	Soil, silt	Land erosion from farms and construction and mining sites
Heavy metals Cause cancer, disrupt immune and endocrine systems	Lead, mercury, arsenic	Unlined landfills, household chemicals, mining refuse, industrial discharges
Thermal Make some species vulnerable to disease	Heat	Electric power and industrial plants

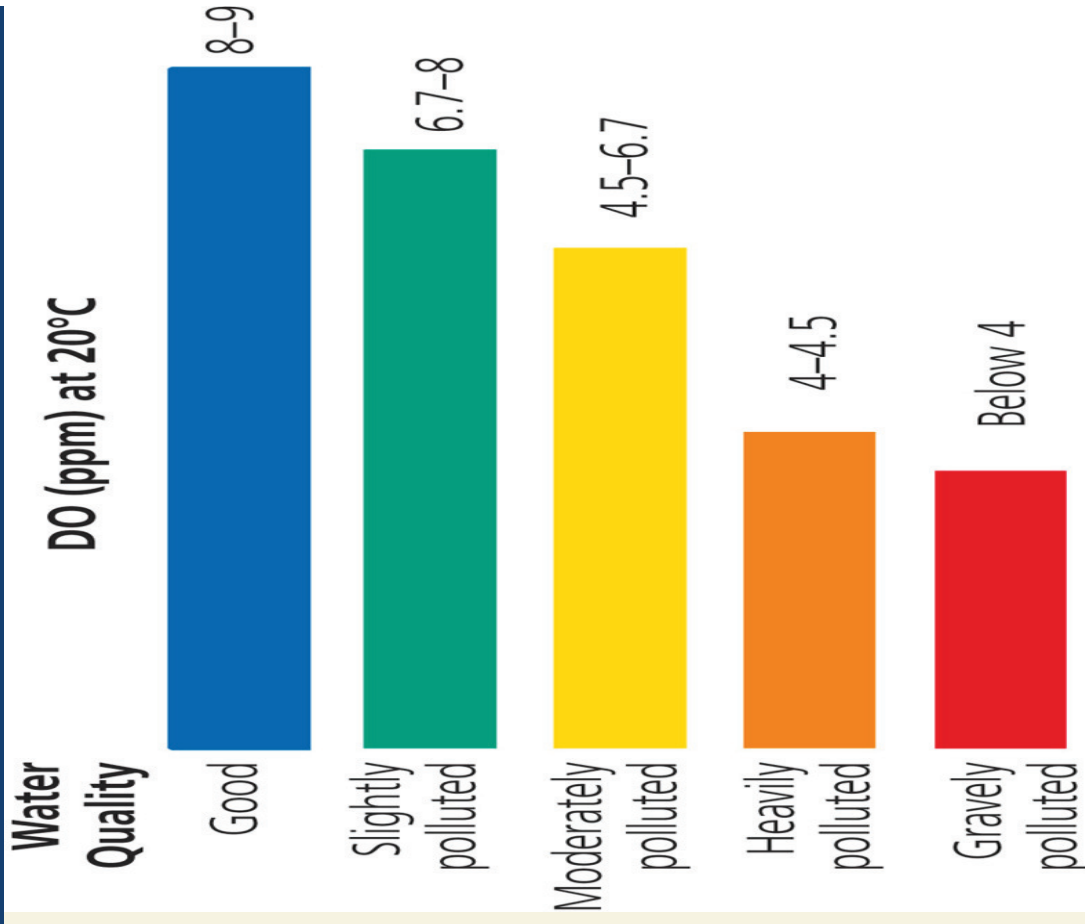
# Common Diseases Transmitted to Humans through Contaminated Drinking Water

**Table 20-2** Common Diseases Transmitted to Humans through Contaminated Drinking Water

Type of Organism	Disease	Effects
Bacteria	Typhoid fever	Diarrhea, severe vomiting, enlarged spleen, inflamed intestine; often fatal if untreated
	Cholera	Diarrhea, severe vomiting, dehydration; often fatal if untreated
	Bacterial dysentery	Diarrhea, bleeding; rarely fatal except in infants without proper treatment
	Enteritis	Severe stomach pain, nausea, vomiting; rarely fatal
Viruses	Infectious hepatitis (Type B)	Fever, severe headache, loss of appetite, abdominal pain, jaundice, enlarged liver; rarely fatal but may cause permanent liver damage
	Poliomyelitis	Fever, diarrhea, backache, sore throat, aches in limbs; can infect spinal cord and cause paralysis and muscle weakness
	Amoebic dysentery	Severe diarrhea, headache, abdominal pain, chills, fever; if not treated can cause liver abscess, bowel perforation, and death
Parasitic protozoa	Giardiasis	Diarrhea, abdominal cramps, flatulence, belching, fatigue
	Cryptosporidium	Severe diarrhea, cramps for up to 3 weeks, and possible death for people with weakened immune systems
	Schistosomiasis	Abdominal pain, skin rash, anemia, chronic fatigue, and chronic general ill health
	Ancylostomiasis	Severe anemia and possible symptoms of bronchial infection

# Science Focus: Testing Water for Pollutants

- Tests to determine water quality
  - Coliform bacteria: *Escherichia coli*, significant levels
  - Level of dissolved oxygen (DO)
  - Chemical analysis
  - Indicator species: Cattails or mussels
  - Bacteria and yeast glow in the presence of a particular toxic chemical
  - Color and turbidity of the water





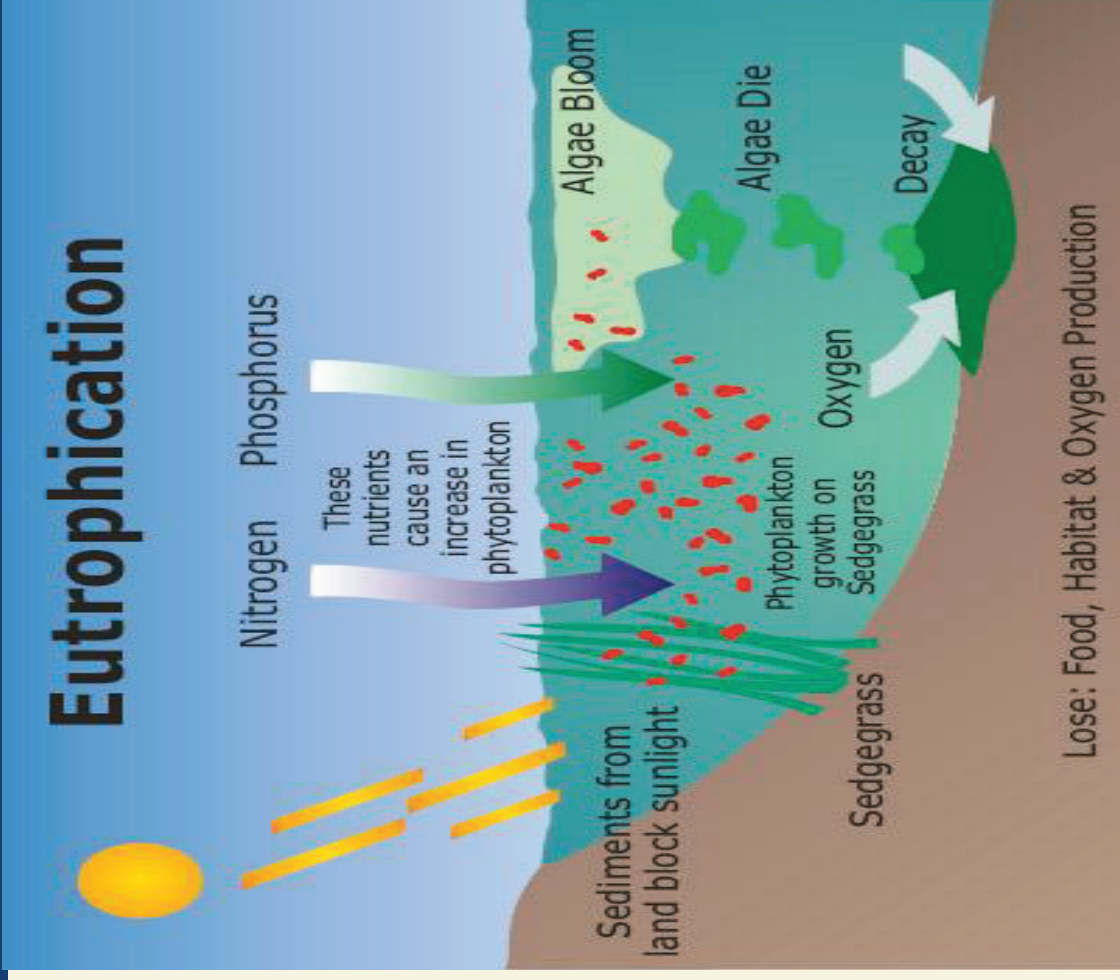
# Eutrophication: Is Too Much of a Good Thing?

## Eutrophication

- Natural enrichment of a shallow lake, estuary, or slow-moving stream
- Caused by runoff into lake that contains nitrates and phosphates

## Oligotrophic lake

- Low nutrients, clear water



# Cultural Eutrophication

- **Cultural eutrophication**
  - Nitrates and phosphates from human sources
  - Farms, feedlots, streets, parking lots
  - Fertilized lawns, mining sites, sewage plants
- During hot weather or droughts
  - Algal blooms
  - Increased bacteria
  - More nutrients
  - Anaerobic bacteria

# Cultural Eutrophication: Prevention & Clean-Up

- Prevent or reduce cultural eutrophication
  - Remove nitrates and phosphates
  - Diversion of lake water
- Clean up lakes
  - Remove excess weeds
  - Use herbicides and algaecides; down-side?
  - Pump in air



# Cultural Eutrophication of Chinese Lake



Fig. 20-11, p. 537

# Principal Sources of Groundwater Contamination in the U.S.

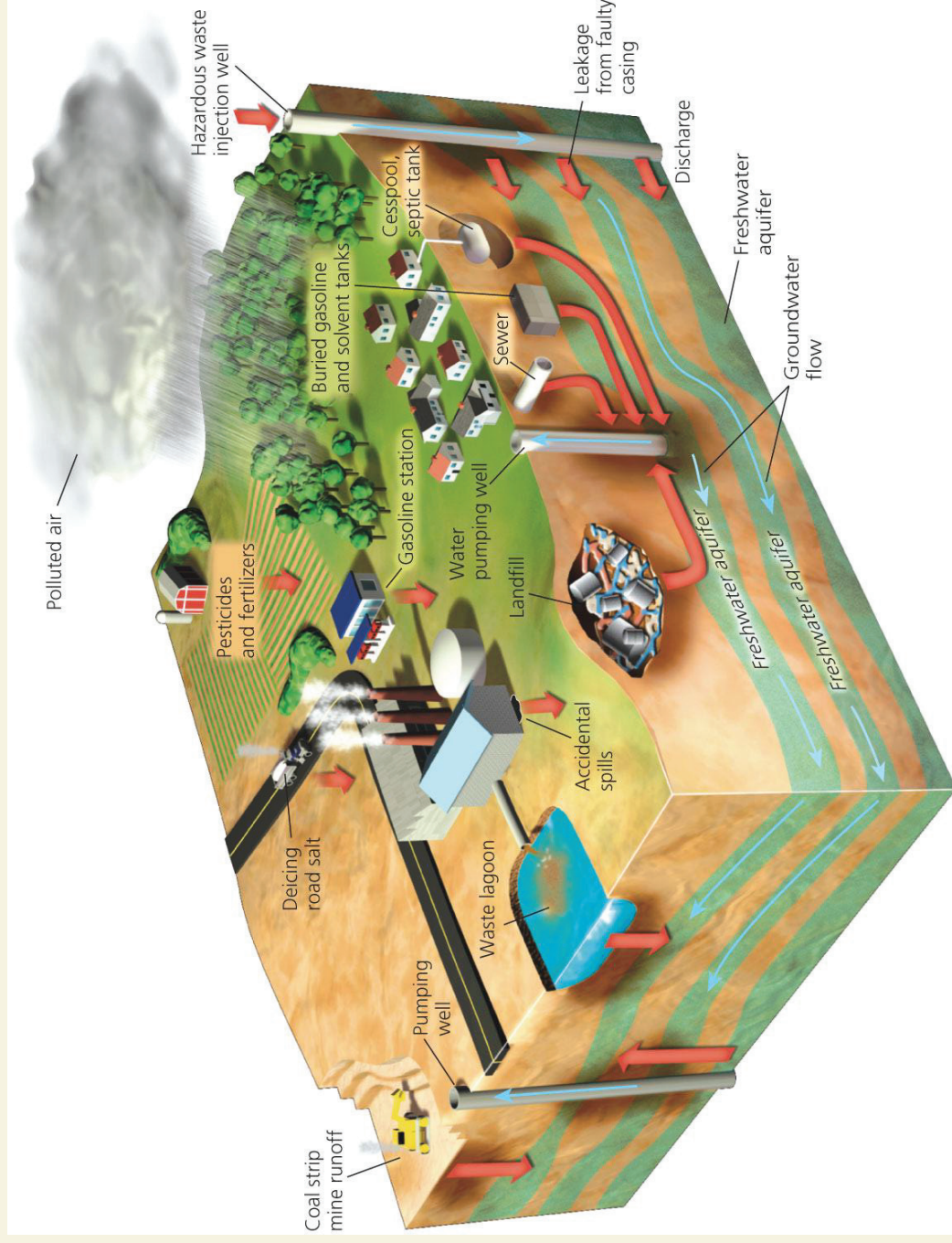


Fig. 20-13, p. 540

# Groundwater Pollution Is a Serious Hidden Threat in Some Areas

- China: 90% of urban aquifers are contaminated or overexploited
- U.S.: FDA reports of toxins found in many aquifers
  - Threats
    - Gasoline, oil
    - Nitrate ions
    - Arsenic



# Pollution Prevention Is the Only Effective Way to Protect Groundwater

- Prevent contamination of groundwater
- Cleanup: expensive and time consuming

# Solutions: Groundwater Pollution, Prevention and Cleanup

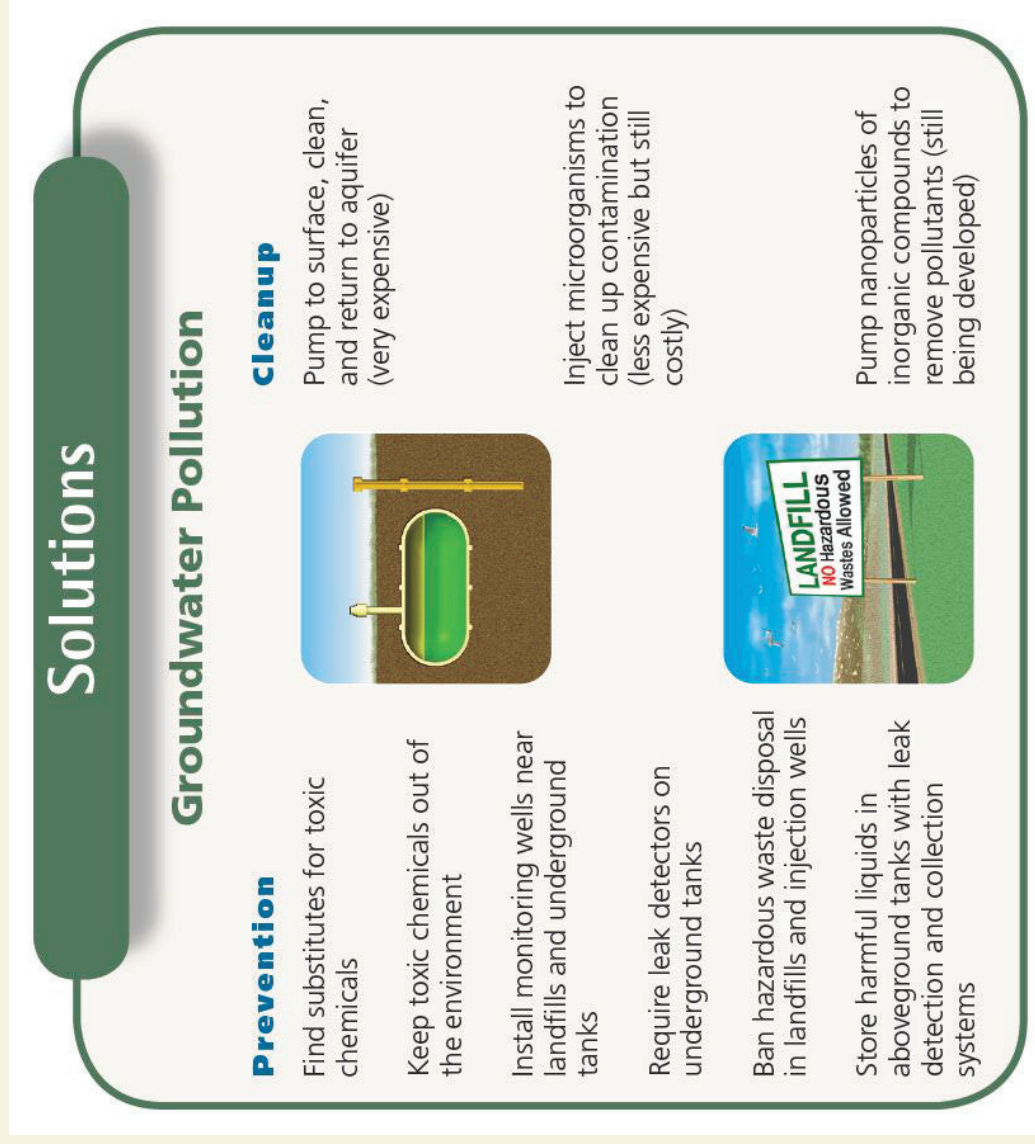


Fig. 20-14, p. 541

# There Are Many Ways to Purify Drinking Water

- Reservoirs and purification plants
- Process sewer water to drinking water
- Expose clear plastic containers to sunlight (UV)
- The LifeStraw
- PUR: chlorine and iron sulfate powder



# The LifeStraw: Personal Water Purification Device



Fig. 20-15, p. 542

# Using Laws to Protect Drinking Water Quality

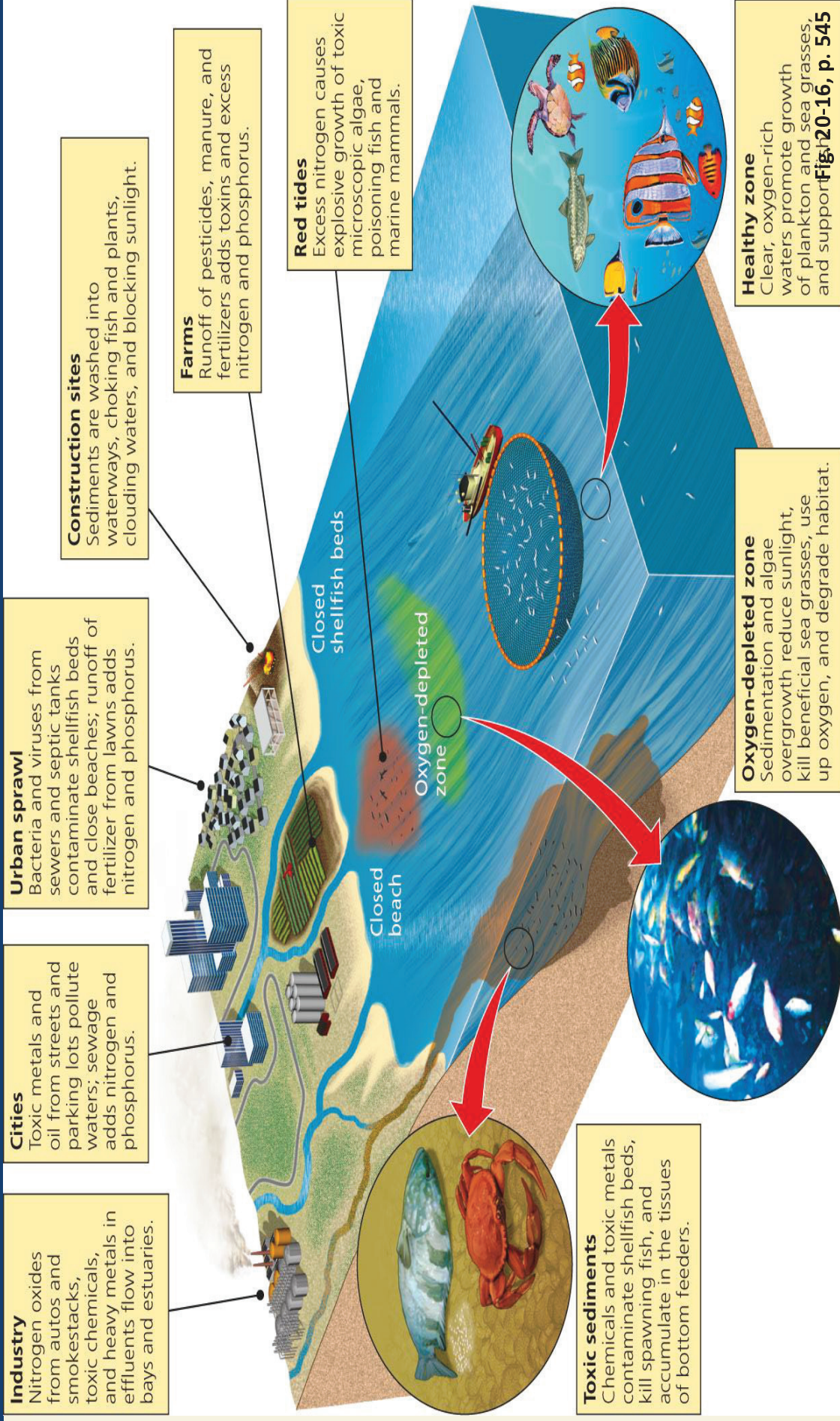
- 1974: U.S. Safe Drinking Water Act
  - Sets maximum contaminant levels for any pollutants that affect human health
- Health scientists: strengthen the law
- Water-polluting companies: weaken the law

# Case Study: Is Bottled Water the Answer?

- U.S.: some of the cleanest drinking water
- Bottled water
  - Some from tap water
  - 40% bacterial contamination
  - Fuel cost to manufacture the plastic bottles
  - Recycling of the plastic
  - 240-10,000x the cost of tap water
- Growing back-to-the-tap movement

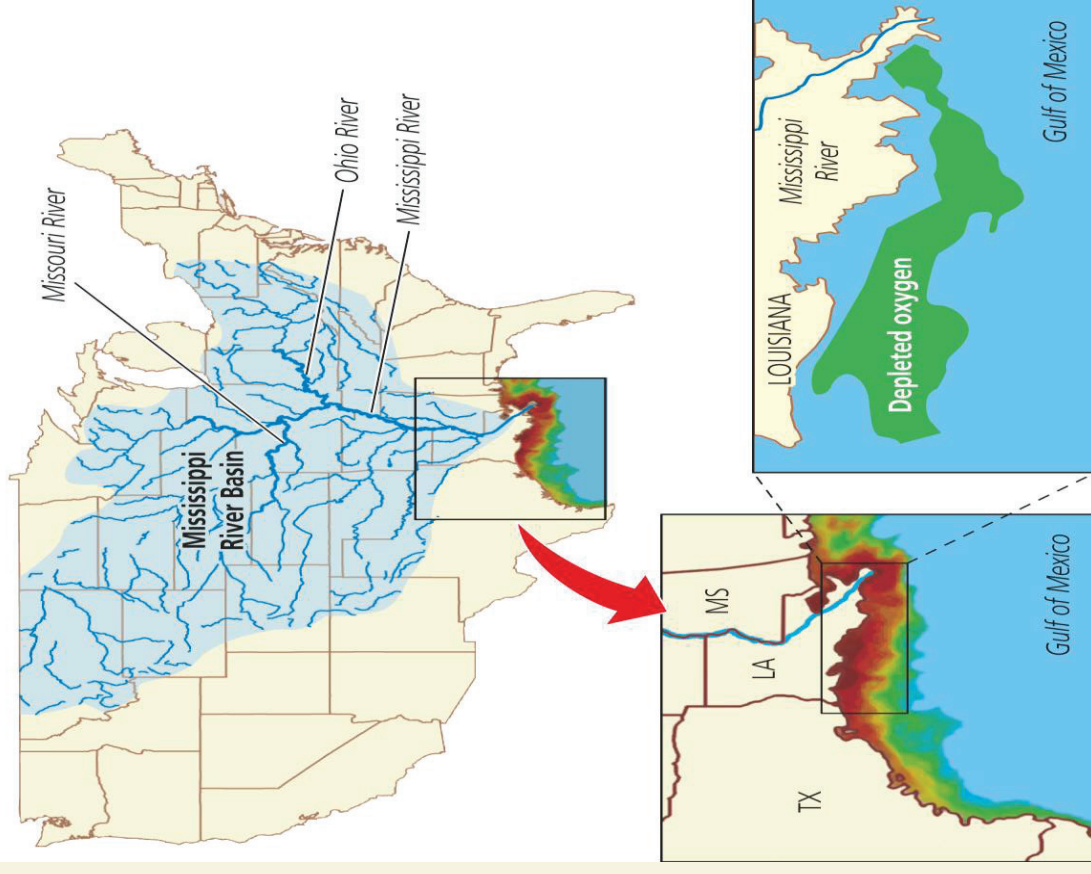


# Residential Areas, Factories, and Farms Contribute to Pollution of Coastal Waters

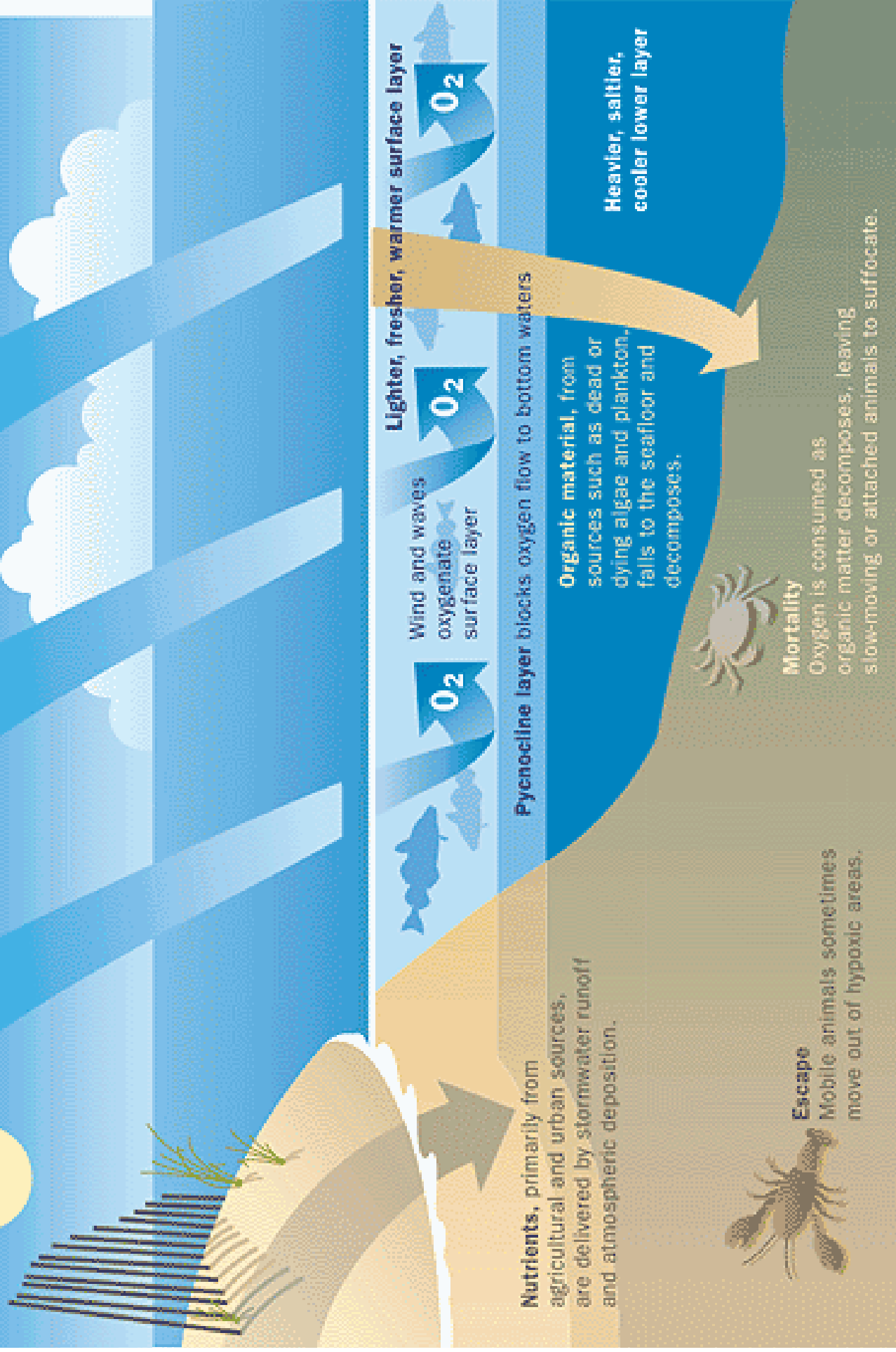


# Science Focus: Oxygen Depletion in the Northern Gulf Of Mexico

- Severe cultural eutrophication
- Oxygen-depleted zone
- Overfertilized coastal area
- Preventive measures
- Will it reach a tipping point?



# The Eutrophication Process





# Ocean Pollution from Oil (1)

- Crude and refined petroleum
  - Highly disruptive pollutants
- Largest source of ocean oil pollution
  - Urban and industrial runoff from land
- 1989: Exxon Valdez, oil tanker
- 2010: BP explosion in the Gulf of Mexico

# Ocean Pollution from Oil (2)

- Volatile organic hydrocarbons
  - Kill many aquatic organisms
- Tar-like globs on the ocean's surface
  - Coat animals
- Heavy oil components sink
  - Affect the bottom dwellers

# Ocean Pollution from Oil (3)

- Faster recovery from crude oil than refined oil
- Cleanup procedures
- Methods of preventing oil spills

# The dangers of oil pollution for marine animals

One metric ton of oil pollutes an area of 12 square kilometers

## Direct contact with oil

Oil affects the protective outer coat of birds, fish and mammals (feathers, scales, fur); it breaks down the insulating capacity of feathers and fur, and hinders movement and other functions

Death of fish,  
marine mammals and birds



## Breakdown of gas exchange

The film of surface oil results in a lack of oxygen in the water

Death of plankton  
and fish



Starvation of animals  
eating plankton and fish



## Poisoning

Oil poisons marine animals if ingested or when it saturates mucous membranes or outer coats

Death and development of genetic  
mutations in fish, shellfish, marine  
mammals, reptiles and birds



Poisoning of other animals (including humans)  
eating fish or marine animals whose meat  
accumulates oil residues





# 20-5 How Can We Best Deal with Water Pollution?

- **Concept 20-5** Reducing water pollution requires we prevent it, work with nature to treat sewage, cut resource use and waste, reduce poverty, and slow population growth.

# Reducing Surface Water Pollution from Nonpoint Sources

- Agriculture
  - Reduce erosion
  - Reduce the amount of fertilizers
  - Plant buffer zones of vegetation
  - Use organic farming techniques
  - Use pesticides prudently
  - Control runoff
- Tougher pollution regulations for livestock operations
- Deal better with animal waste

# Laws Can Help Reduce Water Pollution from Point Sources

- 1972: Clean Water Act
- 1987: Water Quality Act
- EPA: experimenting with a discharge trading policy that uses market forces
  - Cap and trade system
  - Could this allow pollutants to build up?

# Sewage Treatment Reduces Water Pollution (1)

- **Septic tank system**
- Wastewater or sewage treatment plants
  - **Primary sewage treatment**
    - Physical process
  - **Secondary sewage treatment**
    - Biological process with bacteria
  - Tertiary or advance sewage treatment
    - Special filtering processes
    - Bleaching, chlorination



# Sewage Treatment Reduces Water Pollution (2)

- Many cities violate federal standards for sewage treatment plants
- Should there be separate pipes for sewage and storm runoff?
- Health risks of swimming in water with blended sewage wastes

# Solutions: Septic Tank System

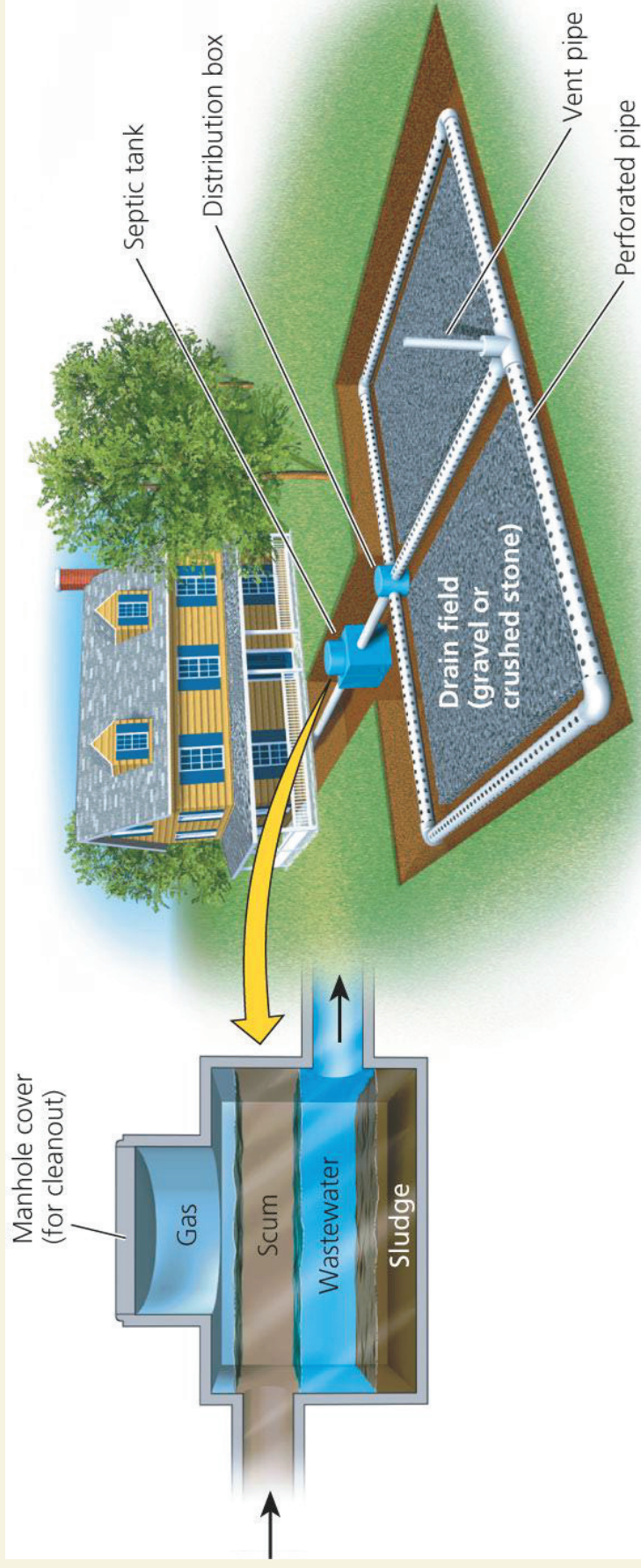


Fig. 20-19, p. 550

# Solutions: Primary and Secondary Sewage Treatment

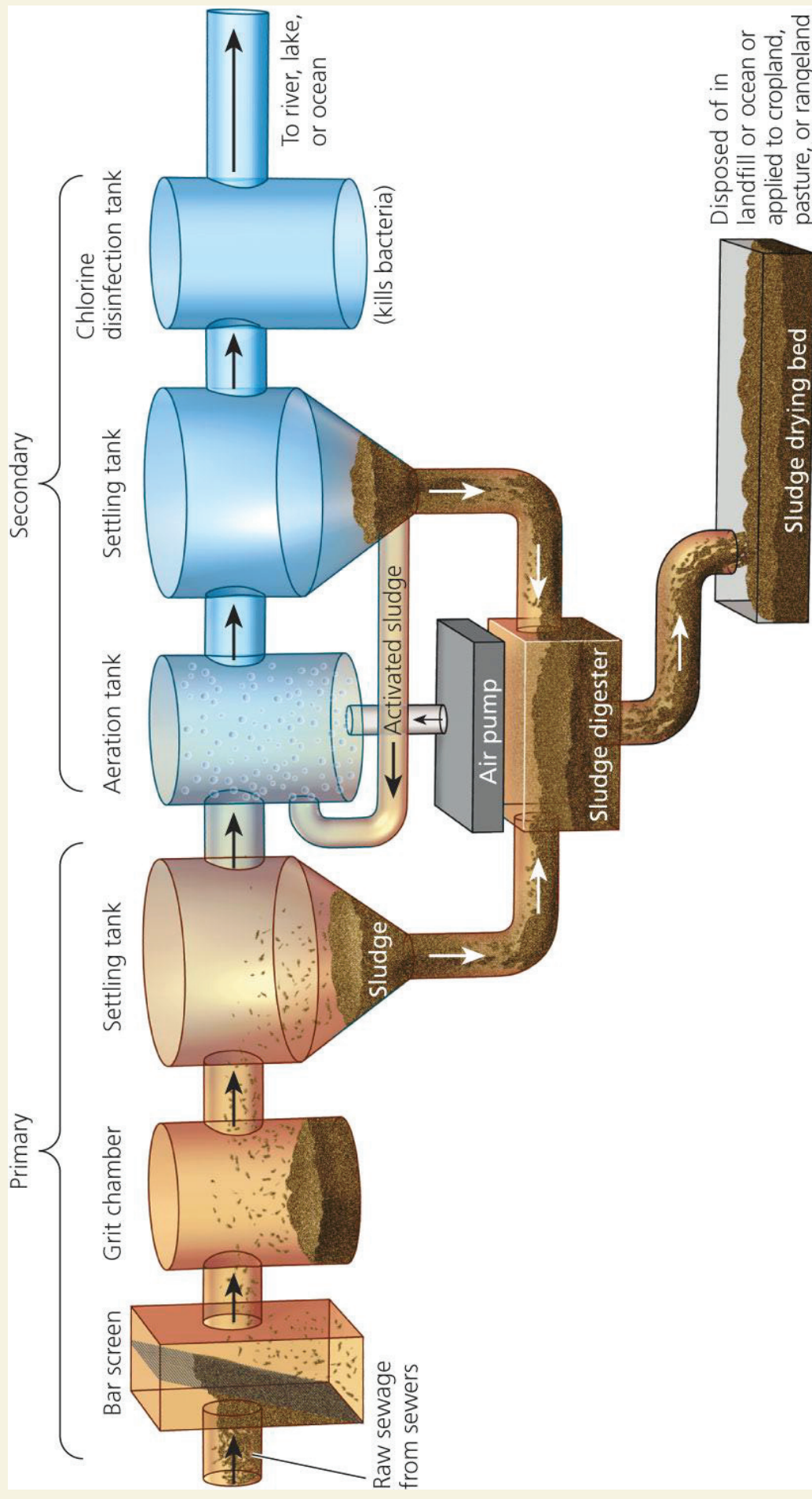


Fig. 20-20, p. 551

# Three Big Ideas

1. There are a number of ways to purify drinking water, but the most effective and cheapest strategy is pollution control.
2. The key to protecting the oceans is to reduce the flow of pollution from land and air, and from streams emptying into ocean waters.
3. Reducing water pollution requires that we prevent it, work with nature in treating sewage, cut resource use and waste, reduce poverty, and slow population growth.