Chapter 15
Air Pollution and Stratospheric Ozone Depletion

Chattanooga Tennessee, Lookout Mountain

4/10 Agenda

Read Opening Story CH 15 Cleaning up in Chattanooga
Warm up
Do the Math CH 15
Sarah– Current Event
Go over Answers for CH 15 MC Study Guide
Discuss Lab: Waste & CO2
Notes CH 15 P.25NB

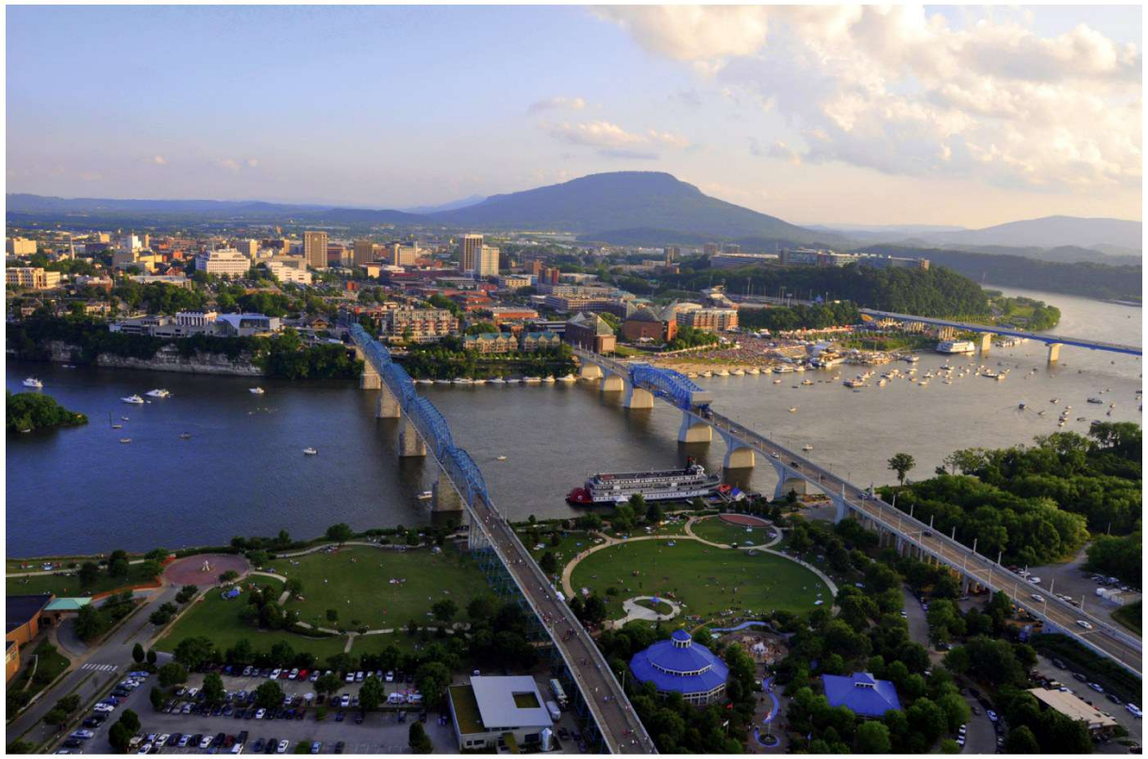
Possible AP FRQ CH 14 & 15 Quiz Thursday 2001#4, 2007#1, 2009 #3, 1999#3, 2000#1, 2001#3, 2002#1, 2004#1, 2006#2, 2007#3, 2007 #4, 2008#1, 2009#1, 2010#1

Cleaning Up in Chattanooga
Read the story P.409 ESBK P. 24 NB AXES

Chapter 15 Opener
Environmental Science

12/4 Air Pollutants Review Topic VI CH 15

Obj. TSW identify the major air pollutants and where they come from. P. 58NB



Chapter 15 Opener
Environmental Science

1. Identify the major air pollutants.
2. Where do each of them come from?
3. How are photochemical smog & acid deposition formed.

4/11 agenda

- Warm up
- Pollution Topic 25 – 30% of AP Test
- Env. Current Events: Amanda, Susan, Sariya, Brianna 4/23
- Lab – Waste & CO_2 Production (Data table) p. 25 NB
- Do the Math CH 14 p.25 NB
- Study your FRQ from CH 15 Voc. Sheet
- Article Bolstering a Link between Alzheimer's Disease & Lead Exposure p.23 NB

12/5 Stratospheric Ozone & Indoor Air Pollution CH 15

Obj. TSW learn the benefit of Stratospheric Ozone, how it is formed and the causes and effects of it's depletion. P. 60 NB

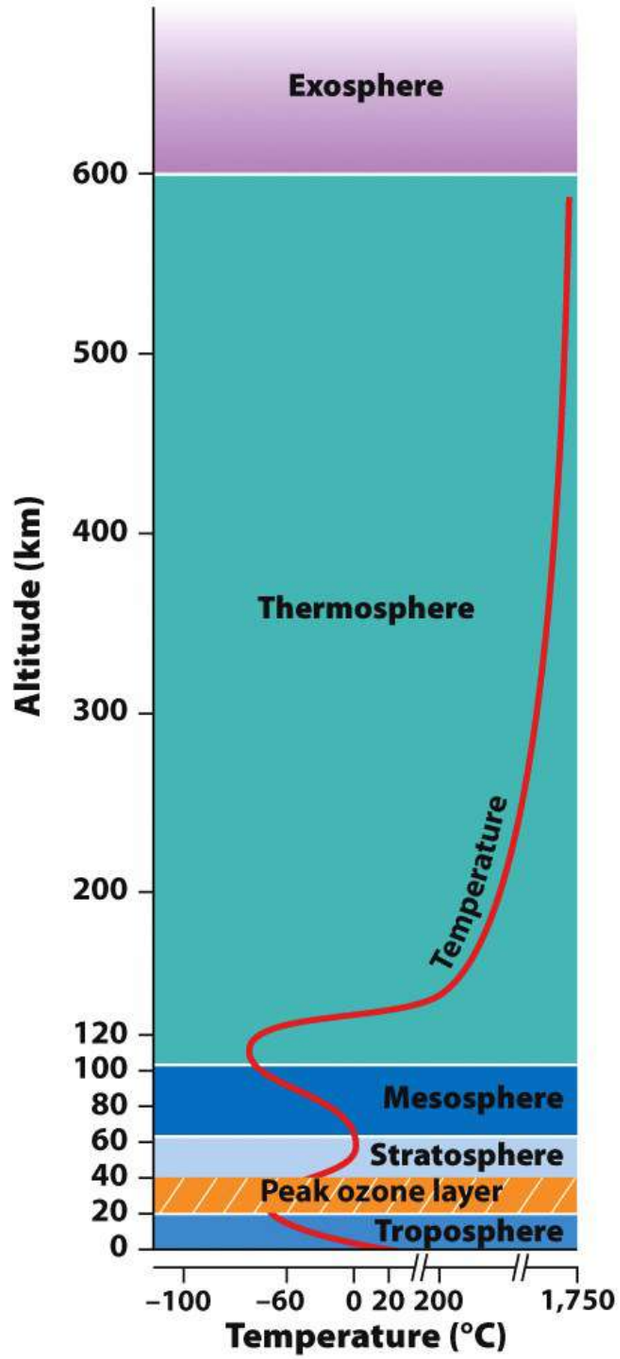


Figure 4.1
Environmental Science

1. What are the equations in the formation and depletion of the closed loop cycle of stratospheric ozone.
2. Explain the causes and effects of stratospheric ozone depletion.
3. Discuss the hazard of indoor air pollution, especially in developing countries.

12/12 Agenda

- 11:42 – 11:52 Warm Up
- 11:52 – 12:00 Explanation & Answers
- 12:00 – 12:10 Env. Sci. current event: Lupita & Zuzeth
- 12:15 turn in NB P. 62 – 69, 53 Lead AXES para, 57Math-% change, & 59 Data table waste lab
- 12:25 start quiz CH 14 & 15 (37minutes) (McAllister leaves at 12:40)
- 1:02 Finish Quiz

- Get HW CH 16 & 17 MC & Voc Study Guides
- CH 16 Due Monday; CH 17 Due Tuesday
- Topic VI Test Wednesday Dec. 18th (CH 14 – 17)

5/1 Water & Air Pollution Review CH 14

Obj. TSW discuss thermal,& noise pollution and our Nations water laws. P. 44 NB

Figure 14.19
Environmental Science

TABLE 14.1 The maximum contaminant levels (MCL) for a variety of contaminants in drinking water as determined by the U.S. Environmental Protection Agency, in parts per billion (ppb)

Contaminant category	Contaminant	Maximum contaminant level (ppb)
Microorganism	Giardia	0
Microorganism	Fecal coliform	0
Inorganic chemical	Arsenic	10
Inorganic chemical	Mercury	2
Organic chemical	Benzene	5
Organic chemical	Atrazine	3

Source: U.S. Environmental Protection Agency, http://www.epa.gov/safewater/contaminants/index.html.

Table 14.1
Environmental Science

1. Discuss what thermal pollution is and a solution to the problem.
2. Why is Noise considered water pollution?
3. What are some of our Nations water laws?

12/8 Agenda

- Warm up, pg. 62
- Air Pollution Presentations, pg.
- CH 15 Opening Story
- Ozone Pollution Video, pg.

- HW:
- CH 16 MC SG due tomorrow, pg. 61
- CH 16 Vocab due Wednesday, pg. 63
- Bring in card decks and silver spoons!

12/8 Air Pollution CH 15

Obj. TSW identify and describe primary and secondary pollutants, thermal inversion, and smog present their findings on different types of pollutants , pg. 62

1. What is the difference between a primary and secondary pollutant?

2. Describe Thermal Inversion and draw the graph/diagram that go along with it and "normal conditions".

3. What is smog and what are some approaches to reducing it?

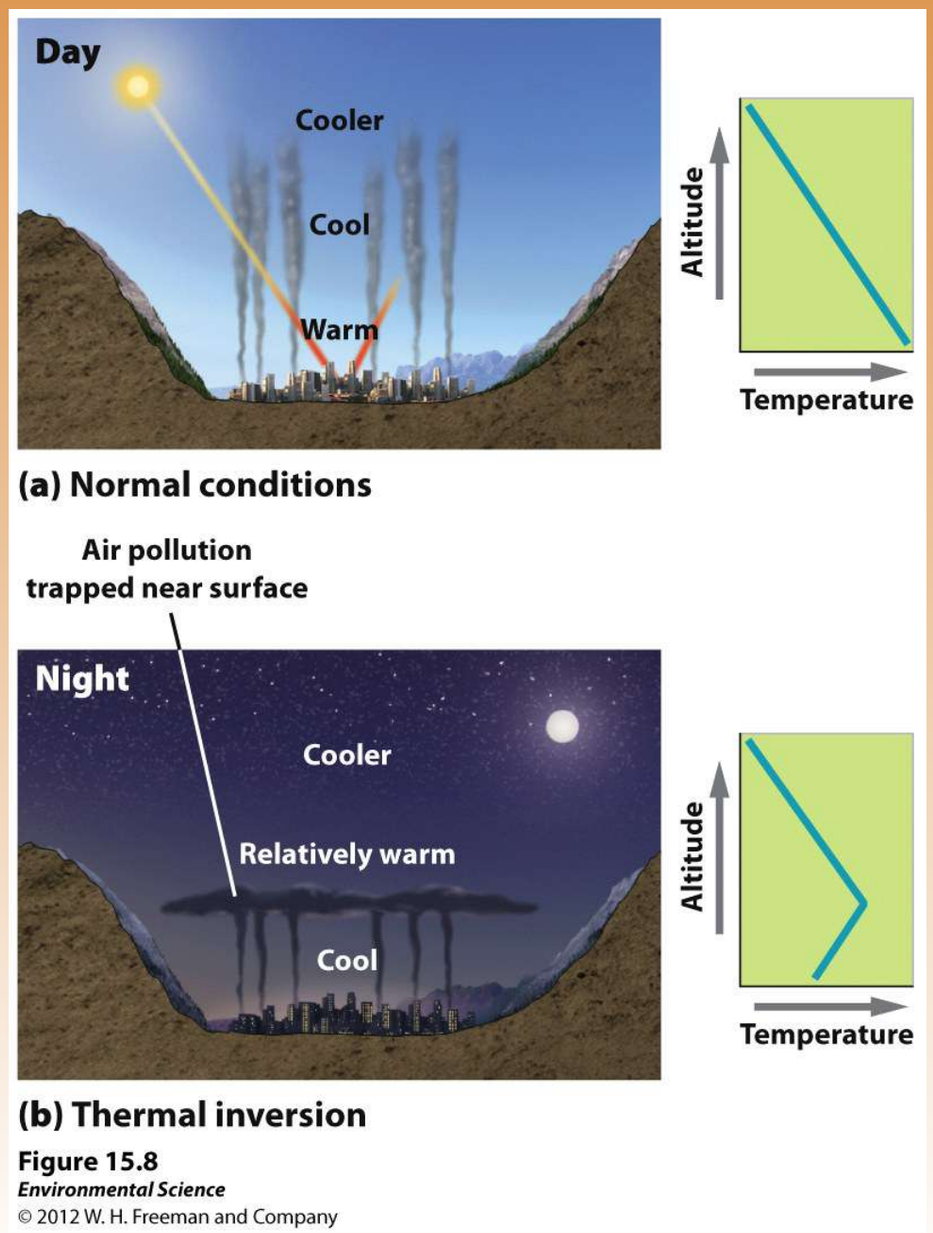


Figure 15.8
Environmental Science

Primary Pollutants

- Primary pollutants- polluting compounds that come **directly** out of the smoke-stack, exhaust pipe, or natural emission source.

- Examples: CO, CO2, SO2, NOx, and most suspended particulate matter.

Figure 15.1
Environmental Science

Secondary Pollutants

- Secondary pollutants- pollutants that have undergone **transformation** in the presence of sunlight, water, oxygen, or other compounds.
- Water and Sunlight involved= does not occur as rapidly at night
- Examples: Ozone, sulfate and nitrate

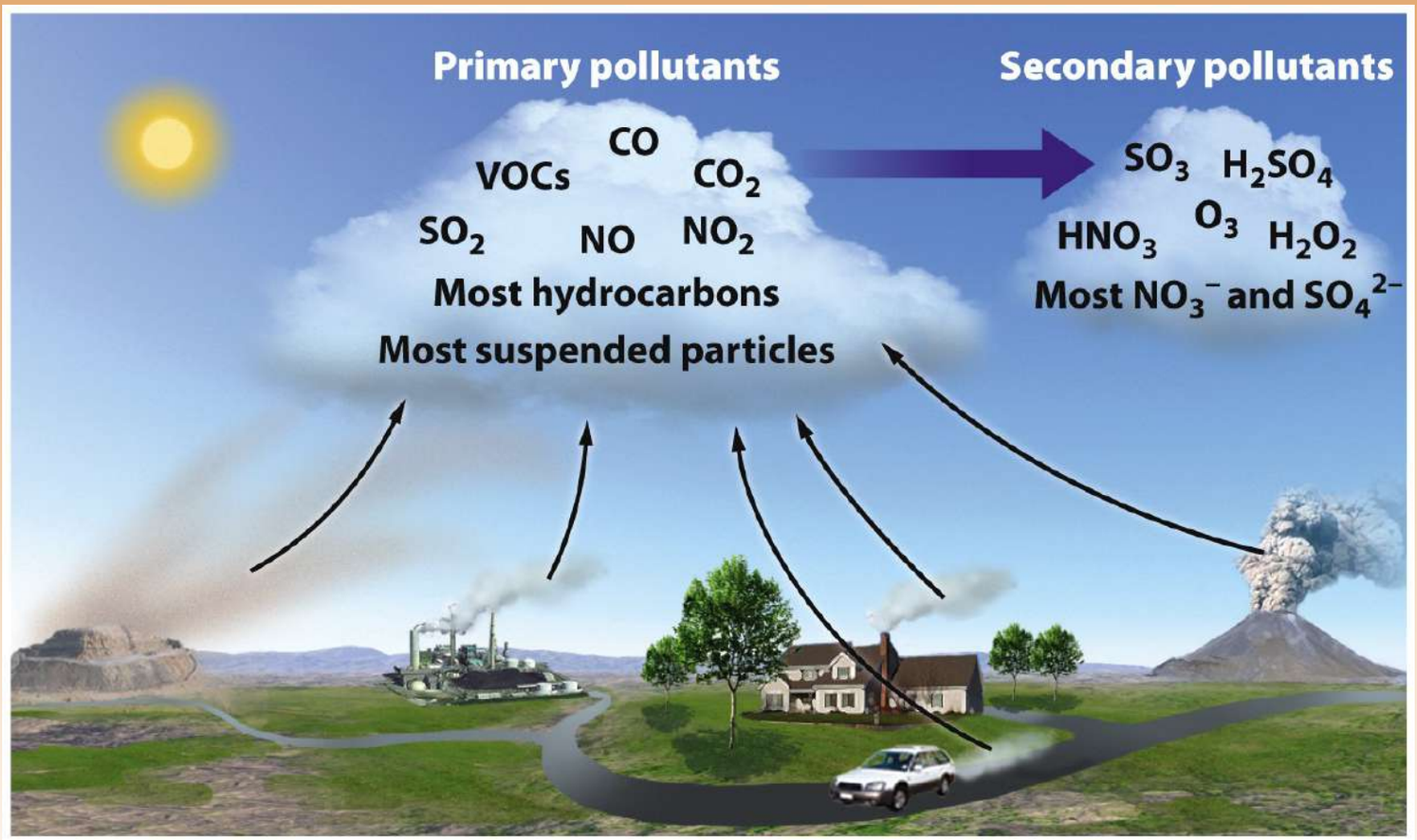


Figure 15.3
Environmental Science

Thermal Inversions

- Normal Conditions- Temp. decreases as altitude increases, BUT...
- Thermal Inversion- when a relatively warm layer of air at mid-altitude covers a layer of cold, dense air below.
- The warm inversion layer traps emissions that then accumulate beneath it.
- Common in some cities where high concentrations of vehicle exhaust and industrial emissions are easily trapped
- EX: ??

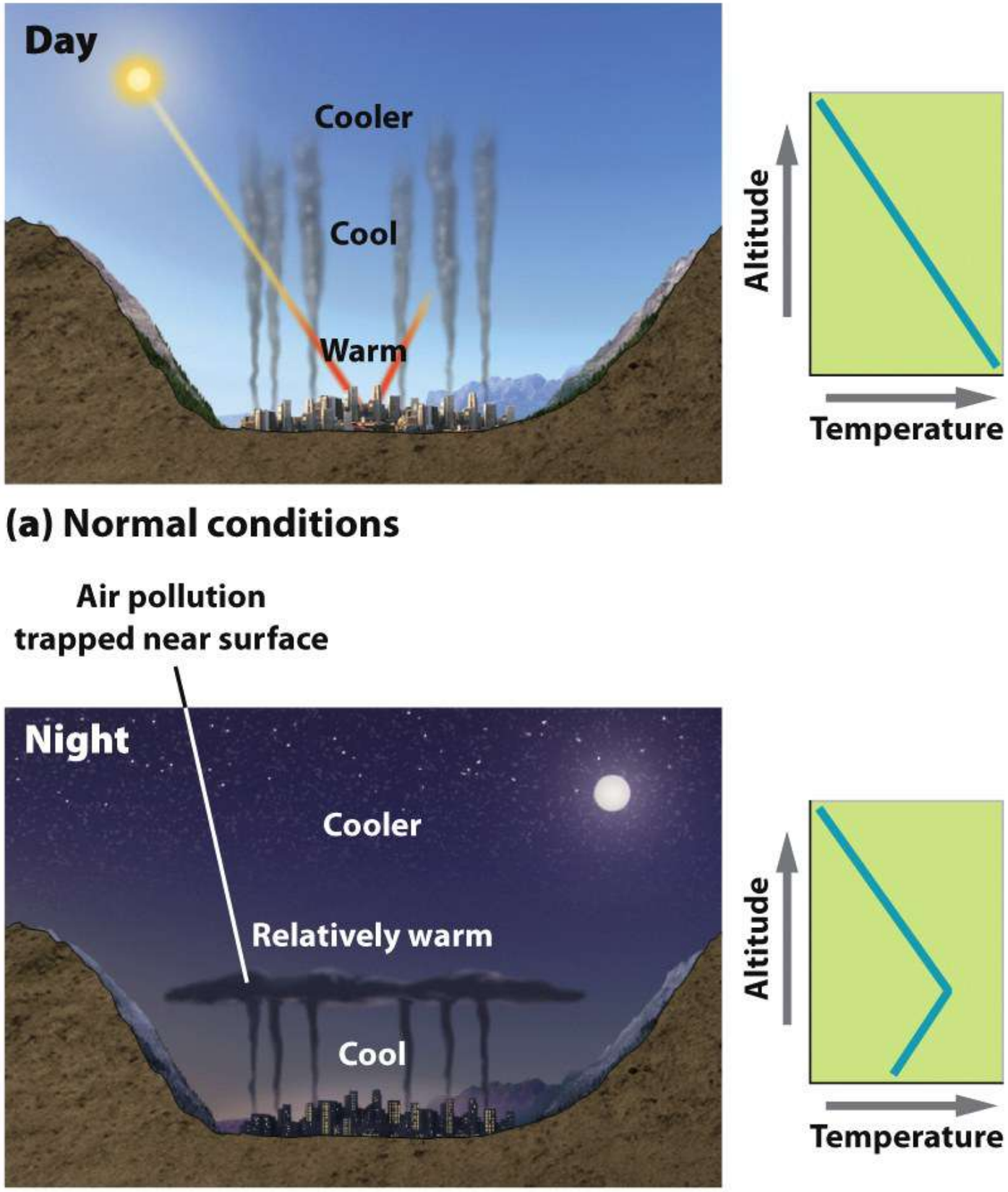


Figure 15.8
Environmental Science

Smog

- Combination of smoke and fog
- Two types:
  - Photochemical smog
  - Sulfurous Smog
- Forms when sunlight, nitrogen oxides, and VOCs are present
- Impairs respiratory function in human beings
- Hard to reduce → secondary pollutant
- Focus on primary pollutants that contribute to smog
  - Reducing VOCs, Nitrogen Oxide emissions

Presentations

- 6 Groups of 3
- Include: Symbol, What causes the pollution? Effects/impacts? Solutions?
- **Sulfur Dioxide**: Magda, Jonathan, Ellie
- **Nitrogen Oxide**: Taylor, Bryan, Brad
- **Carbon Monoxide**: Lovpret, Priya, Mandeep
- **Particulate Matter:** Rachana, Luis, Monica
- **Lead:** Ayat, Matthew, Jeanelle
- **Ozone**: Jasmine, Daniela, Joseph

TABLE 15.1 Major air pollutants

Compound	Symbol	Human-derived sources	Effects/impacts
Criteria air pollutants			
Sulfur dioxide	SO_2	Combustion of fuels that contain sulfur, including coal, oil, gasoline.	Respiratory irritant, can exacerbate asthma and other respiratory ailments. SO_2 gas can harm stomates and other plant tissue. Converts to sulfuric acid in atmosphere, which is harmful to aquatic life and some vegetation.
Nitrogen oxides	NO_x	All combustion in the atmosphere including fossil fuel combustion, wood, and other biomass burning.	Respiratory irritant, increases susceptibility to respiratory infection. An ozone precursor, leads to formation of photochemical smog. Converts to nitric acid in atmosphere, which is harmful to aquatic life and some vegetation. Also contributes to overfertilizing terrestrial and aquatic systems (as discussed in Chapter 3).
Carbon monoxide	CO	Incomplete combustion of any kind, malfunctioning exhaust systems, and poorly ventilated cooking fires	Bonds to hemoglobin thereby interfering with oxygen transport in the bloodstream. Causes headaches in humans at low concentrations; can cause death with prolonged exposure at high concentrations.
Particulate matter	PM_{10} (smaller than 10 micrometers) $PM_{2.5}$ (2.5 micrometers and less)	Combustion of coal, oil, and diesel, and of biofuels such as manure and wood. Agriculture, road construction, and other activities that mobilize soil, soot, and dust.	Can exacerbate respiratory and cardiovascular disease and reduce lung function. May lead to premature death. Reduces visibility, and contributes to haze and smog.
Lead	Pb	Gasoline additive, oil and gasoline, coal, old paint.	Impairs central nervous system. At low concentrations, can have measurable effects on learning and ability to concentrate.
Ozone	O_3	A secondary pollutant formed by the combination of sunlight, water, oxygen, VOCs, and NO_x.	Reduces lung function and exacerbates respiratory symptoms. A degrading agent to plant surfaces. Damages materials such as rubber and plastic.
Other air pollutants			
Volatile organic compounds	VOC	Evaporation of fuels, solvents, paints; improper combustion of fuels such as gasoline.	A precursor to ozone formation.
Mercury	Hg	Coal, oil, gold mining.	Impairs central nervous system. Bioaccumulates in the food chain.
Carbon dioxide	CO_2	Combustion of fossil fuels and clearing of land.	Affects climate and alters ecosystems by increasing greenhouse gas concentrations.

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Table 15.1 part 1
Environmental Science

Acid Deposition

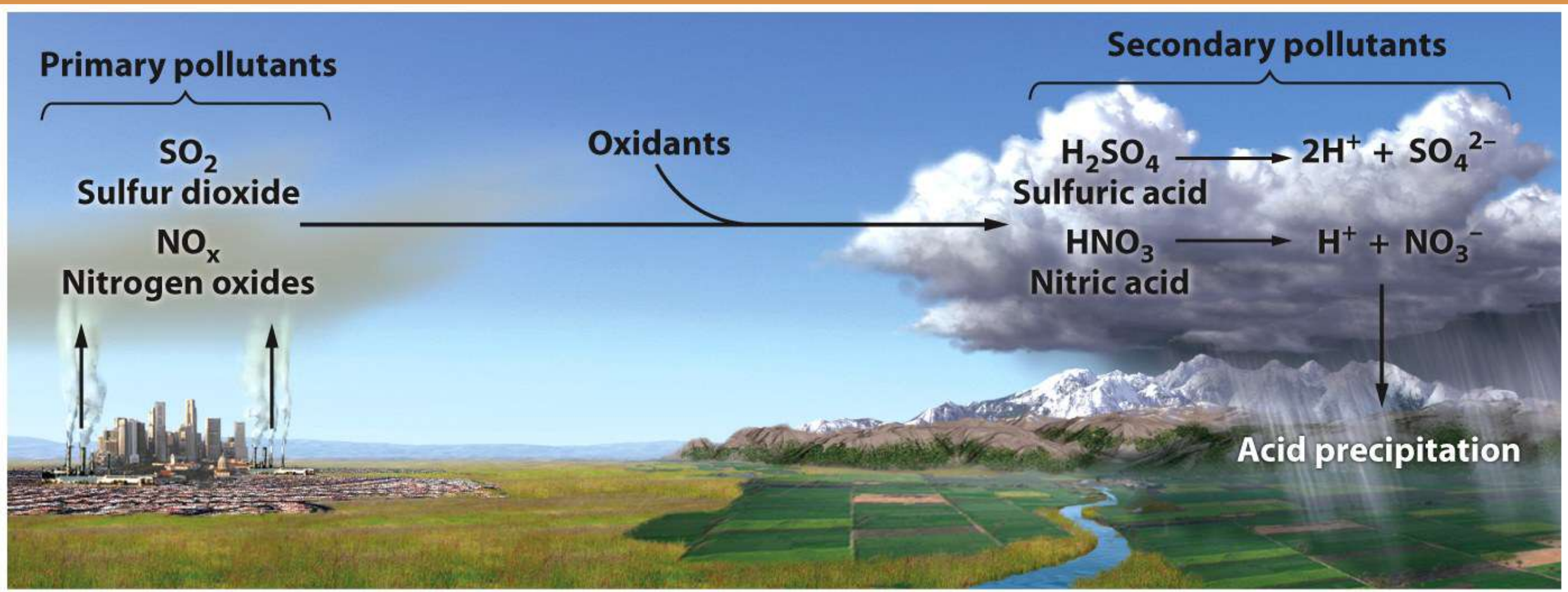

Figure 15.9
Environmental Science

Acid Deposition

- Acid deposition- occurs when nitrogen oxides and sulfur oxides are released into the atmosphere and combine with atmospheric oxygen and water. These form the secondary pollutants nitric acid and sulfuric acid.
- These secondary pollutants further break down into nitrate and sulfate which cause the acid in acid deposition.

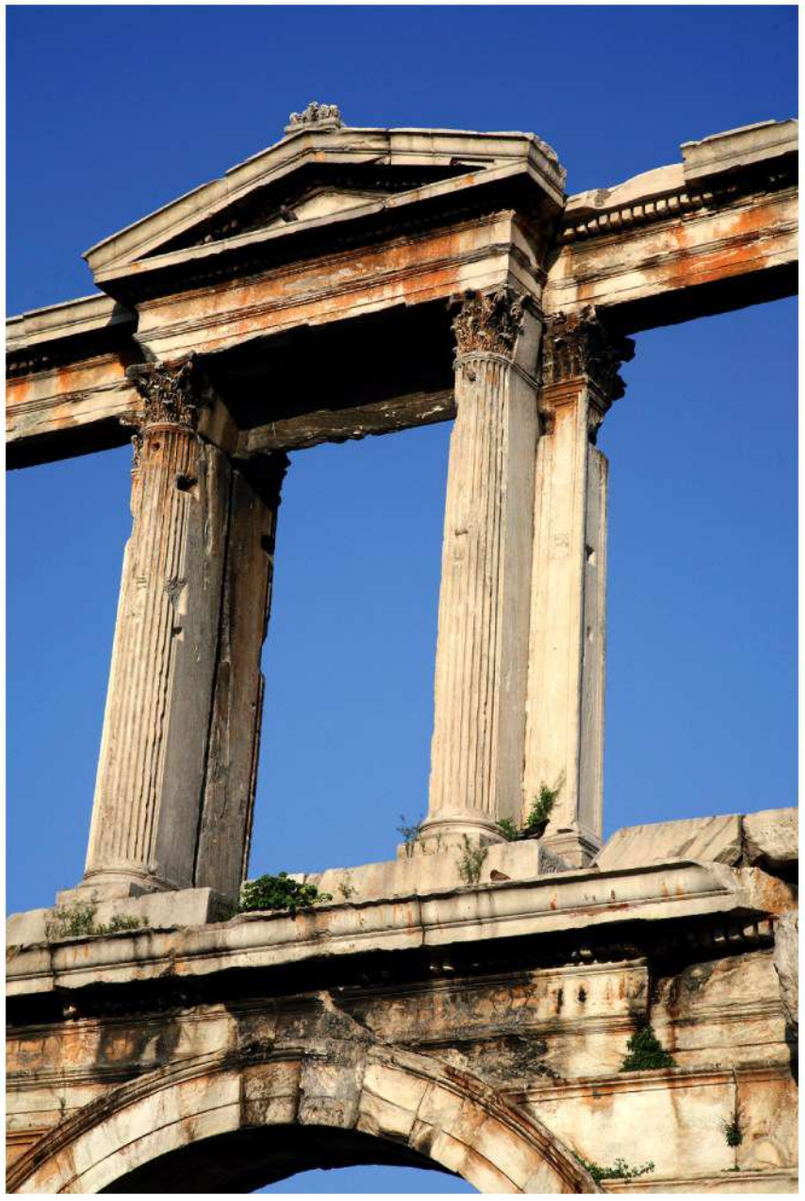

Figure 15.10
Environmental Science

Hadrian's Arch- Athens Greece
Made of Marble which has calcium carbonate. Dry acid in the air and acid rain deteriorate the monument.

Effects of Acid Deposition

- Lowering the pH of lake water
- Decreasing species diversity of aquatic organisms
- Mobilizing metals that are found in soils and releasing these into surface waters
- Damaging statues, monuments, and buildings

Major Air Pollutants

- Sulfur Dioxide
- Nitrogen Oxides
- Carbon Oxides
- Particulate Matter
- Volatiles Organic Compounds
- Ozone
- Lead
- Mercury

Thermal Pollution – Nuclear Reactors

Empty the water into holding ponds before it returns to the river or lake or ocean.

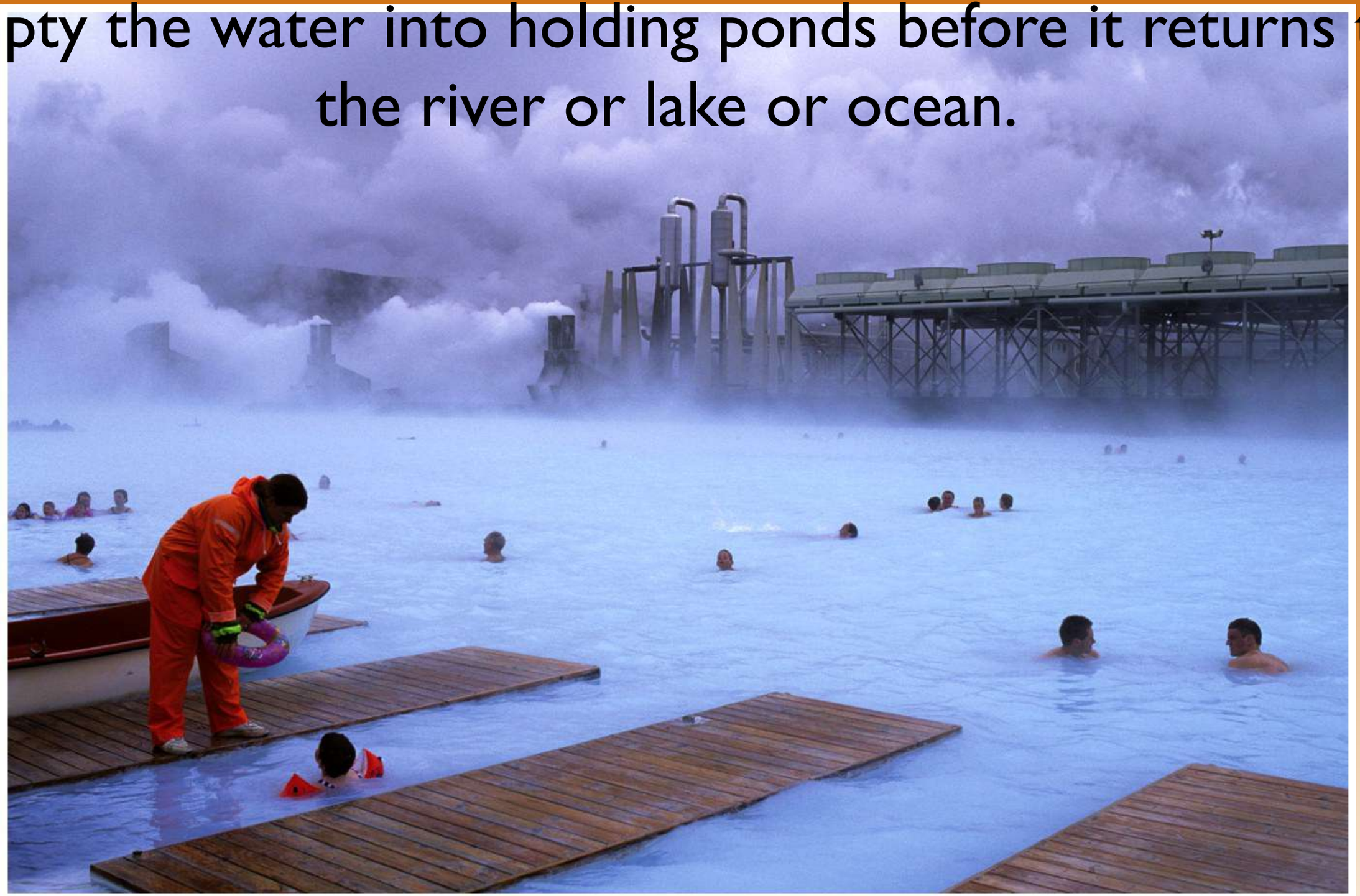

Figure 14.19
Environmental Science

Iceland – Svartsengi Power Plant

Solution – to use a cooling tower to reduce the temperature of water by evaporation.

Air Pollution

- Air pollution- the introduction of chemicals, particulate matter, or microorganisms into the atmosphere at concentrations high enough to harm plants, animals, and materials such as buildings, or to alter ecosystems.

Major Air Pollutants

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- Nitrogen Oxides
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Table 15.1 part 1
Environmental Science

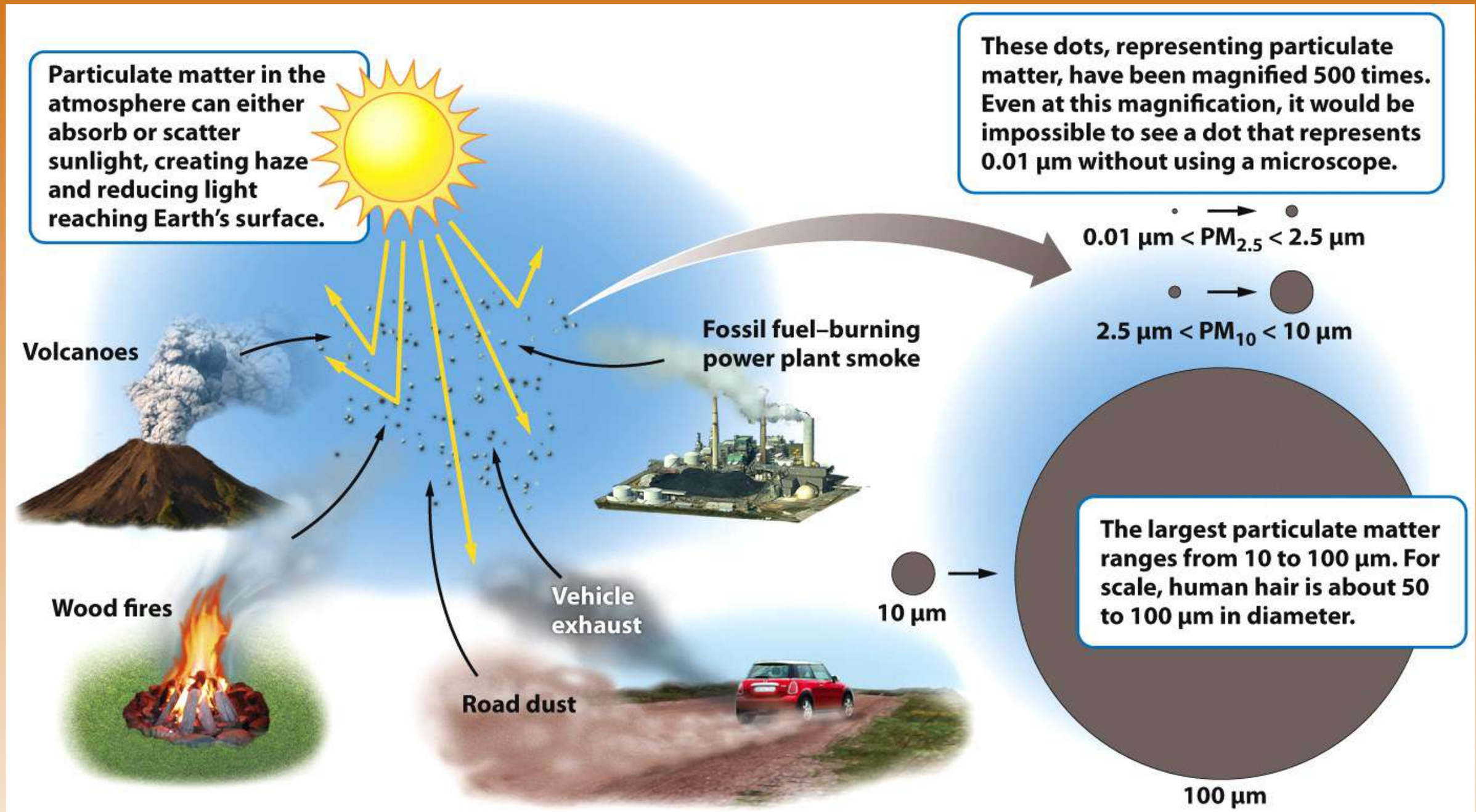

Figure 15.2
Environmental Science

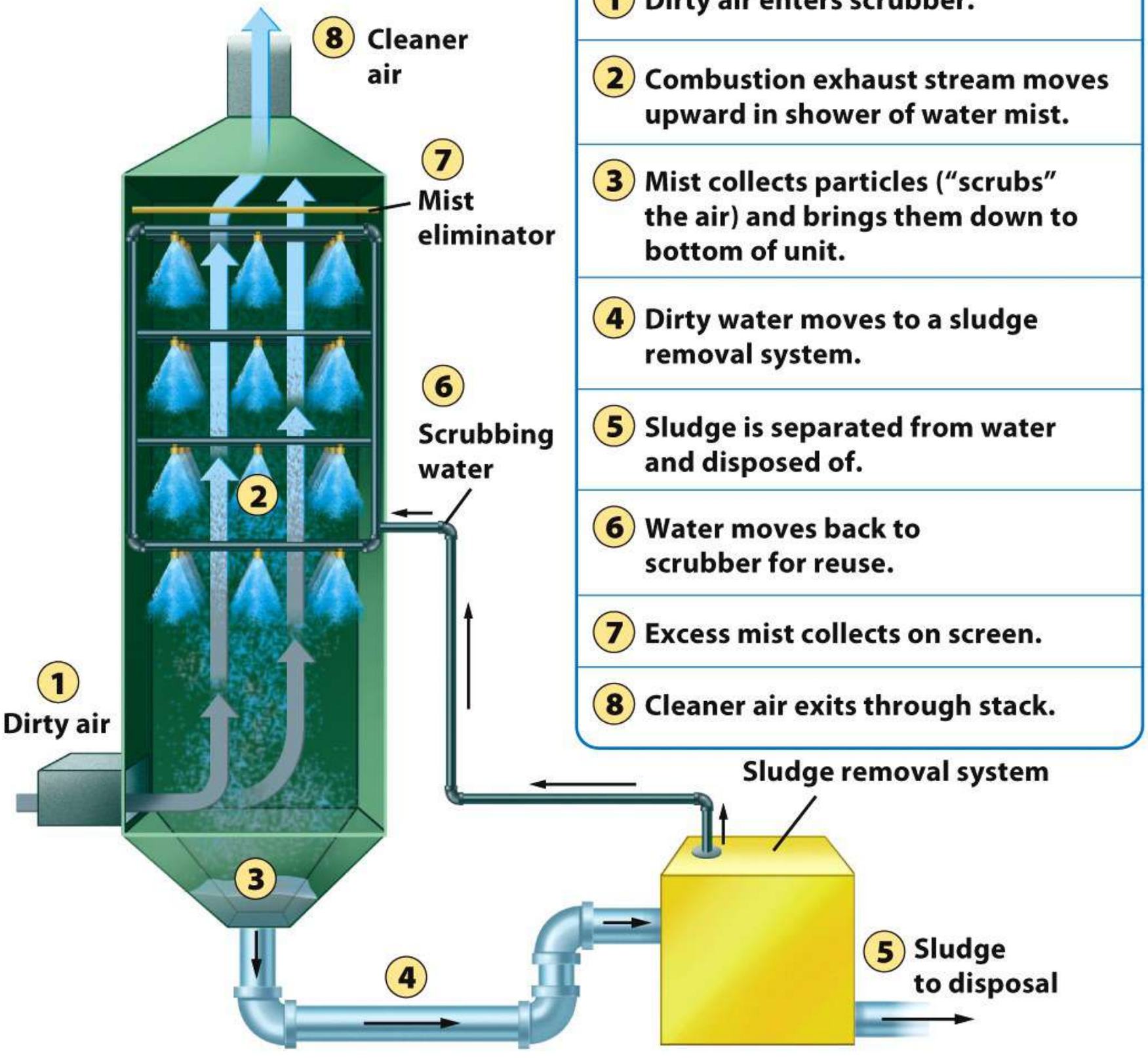

Figure 15.13
Environmental Science

The scrubber
Air Pollution control device
Uses water droplets over the exhaust stream to create a "sludge" that is collected and processed for disposal.

Natural Sources of Air Pollution

- Volcanoes
- Lightning
- Forest fires
- Plants

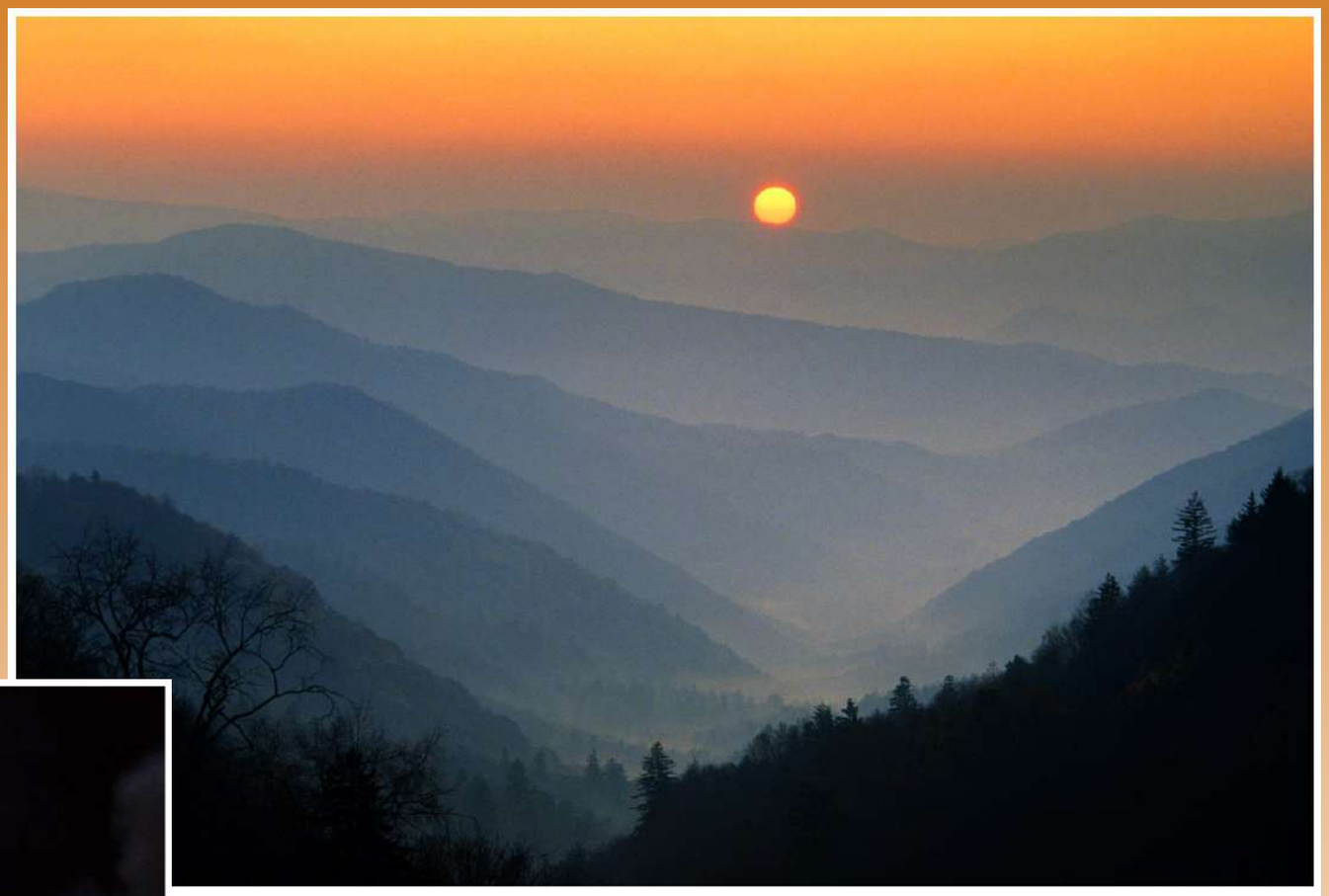

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Figure 15.4a
Environmental Science
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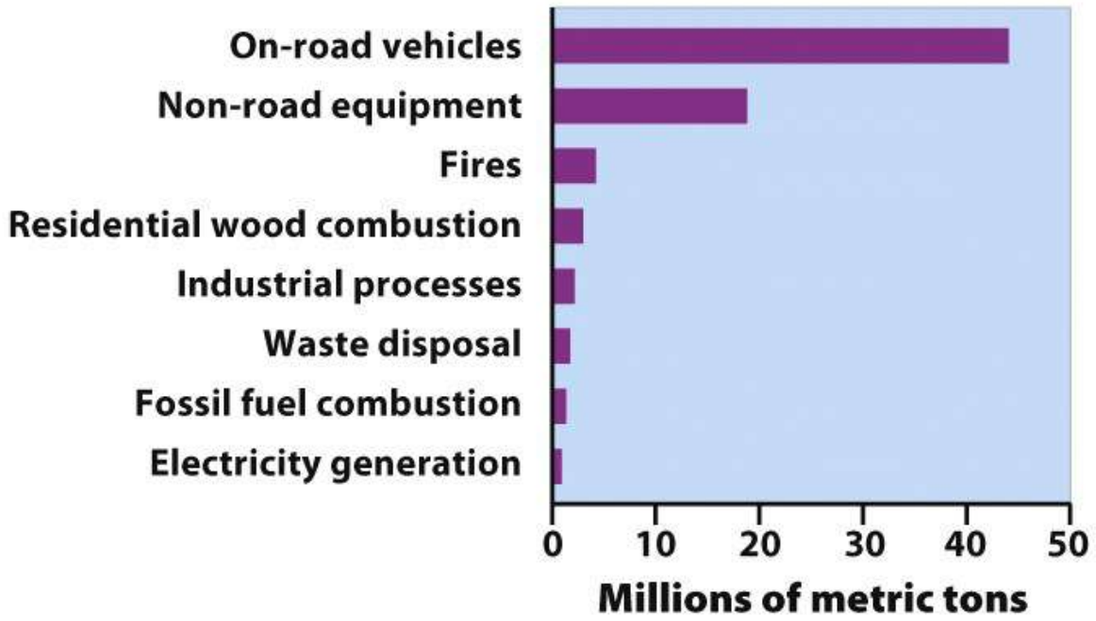
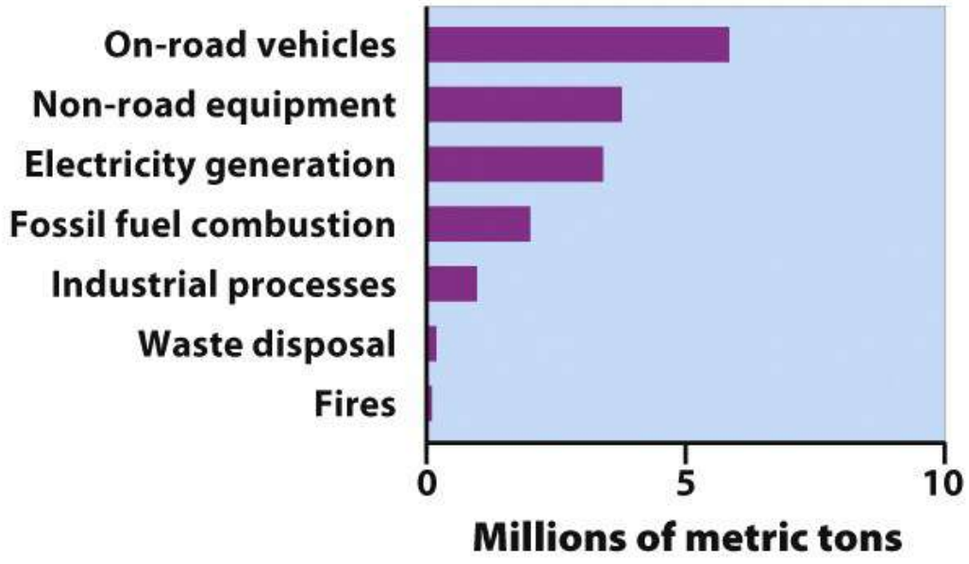
Anthropogenic Sources of Air Pollution

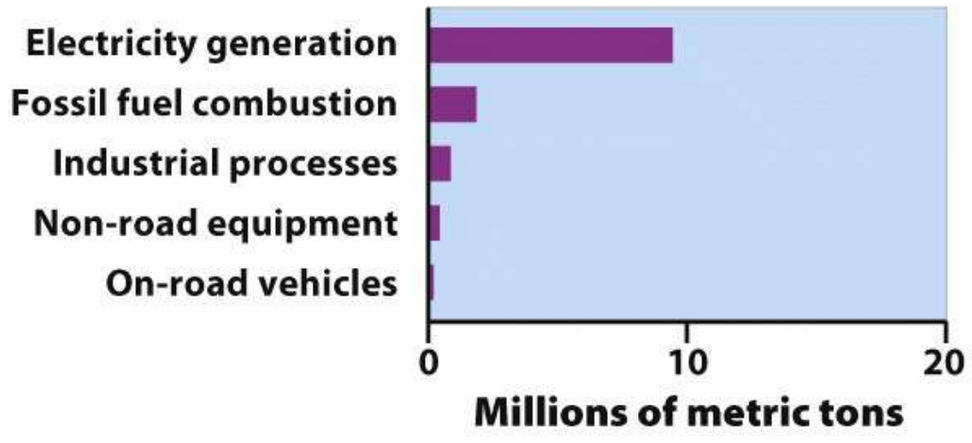
- On-road vehicles
- Power plants
- Industrial processes
- Waste disposal



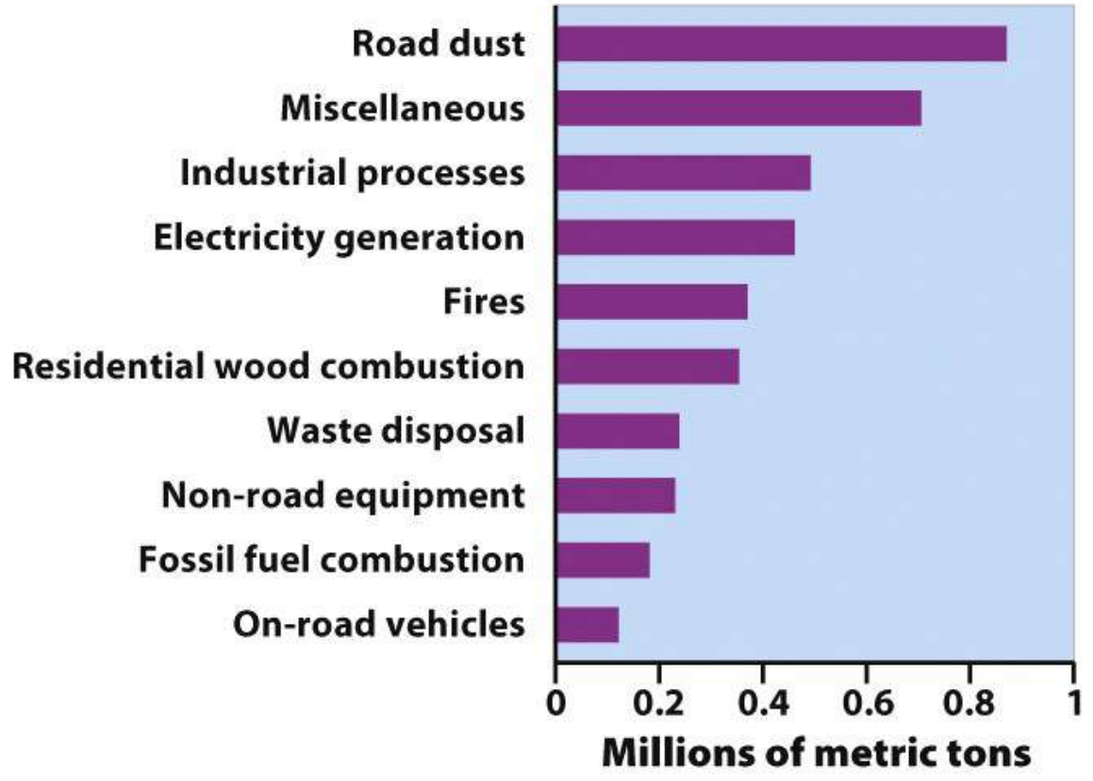
(a) Carbon monoxide



(b) Nitrogen oxides



(c) Sulfur dioxide



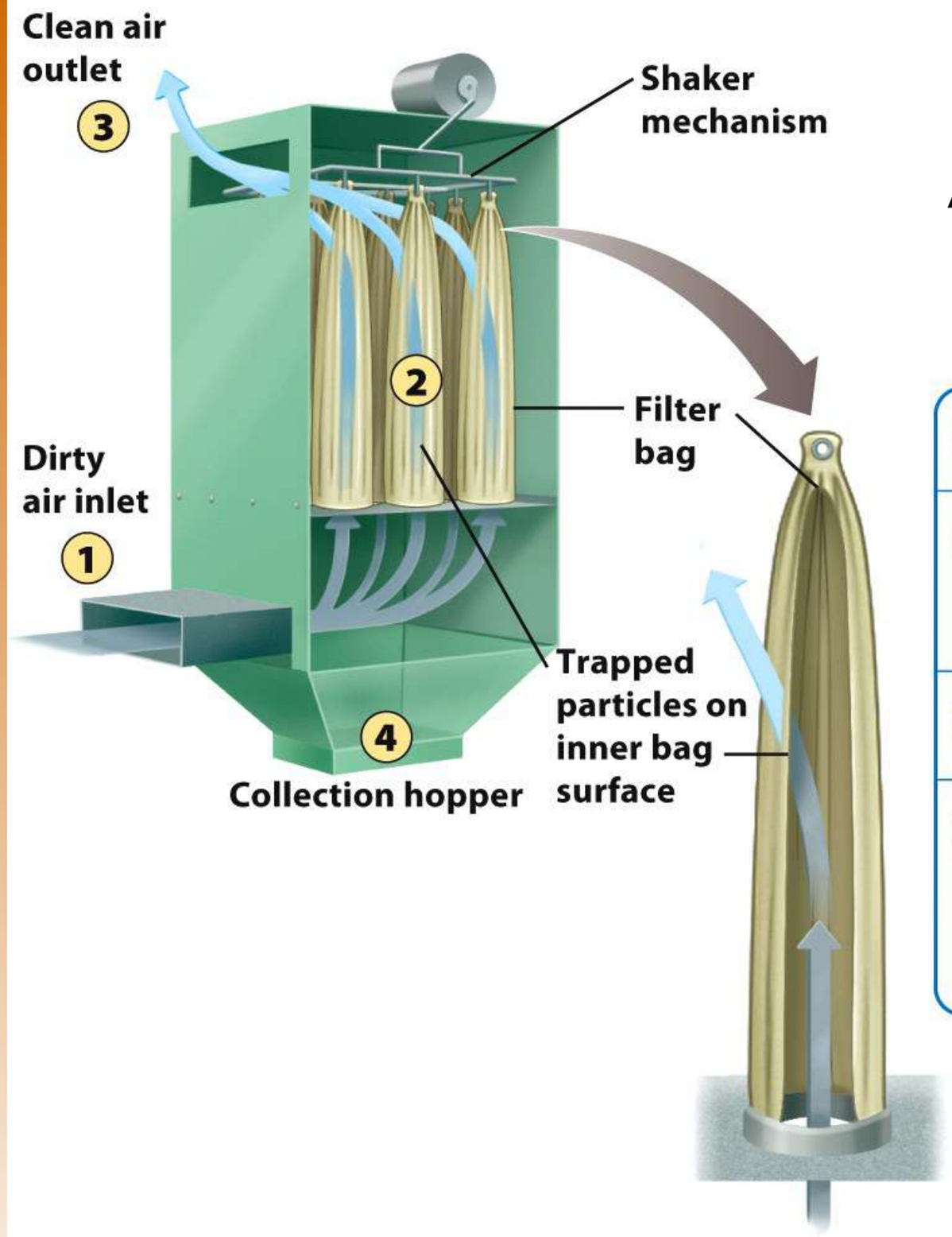
(d) Particulate matter ($PM_{2.5}$)

Figure 15.5
Environmental Science

Ways to Prevent Air Pollution

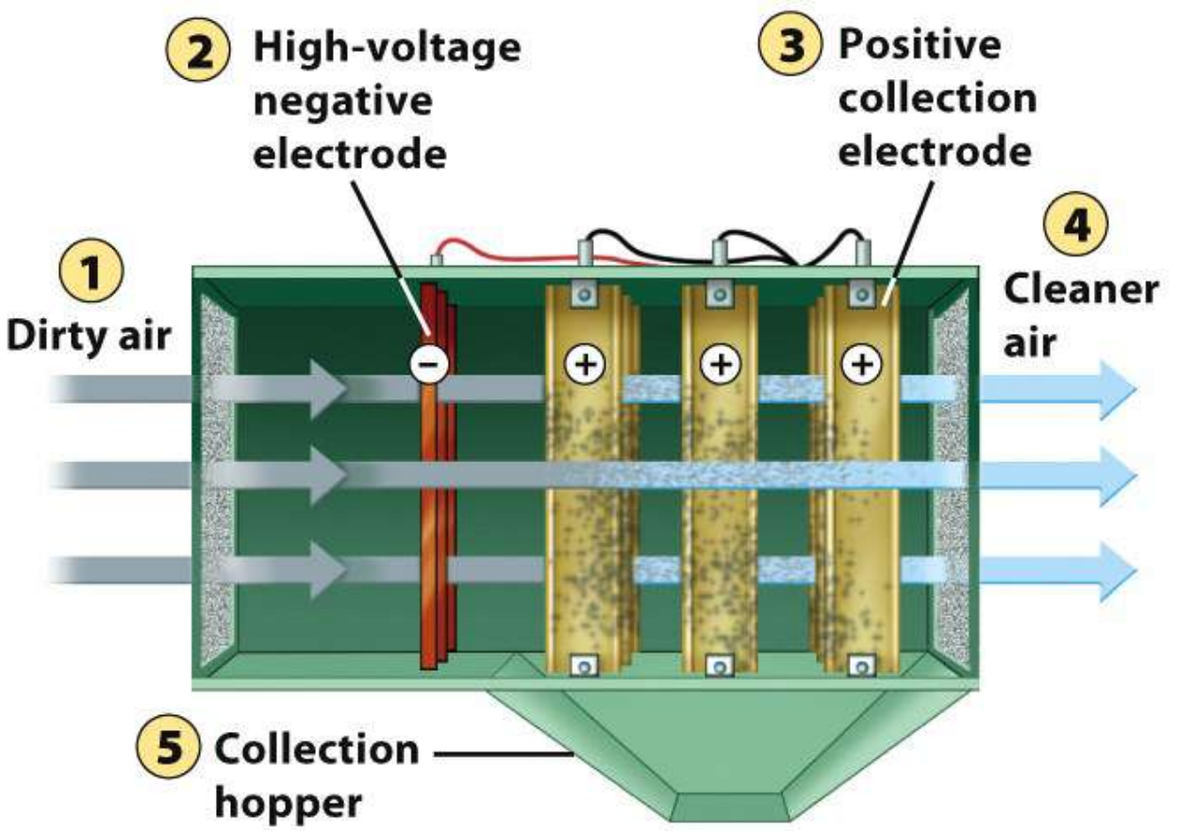
- Removing sulfur dioxide from coal by fluidized bed combustion
- Catalytic converters on cars
- Scrubbers on smoke stacks
- Baghouse filters
- Electrostatic precipitators

Baghouse Filter
Air pollution control device



1. Dirty air enters housing.
2. Combustion exhaust stream moves through and dust particles are trapped in a series of filter bags.
3. Cleaner, filtered air moves out of unit.
4. A shaker mechanism is activated periodically to dislodge trapped particles, which can then be collected from beneath the unit.

Figure 15.11
Environmental Science



1. Dirty air enters precipitator unit.
2. Particles in combustion exhaust stream pass by negatively charged plates, which gives them a negative charge.
3. The negatively charged particles are attracted to positively charged collection plates.
4. Cleaner air moves out of the unit.
5. The positive collection plates are periodically discharged, which causes the particles to fall off so that they can be removed from the system.

Figure 15.12
Environmental Science

Electrostatic Precipitator

-particles are given a negative charge which causes then to be attracted to a positively charged plate. The particles are collected for disposal.

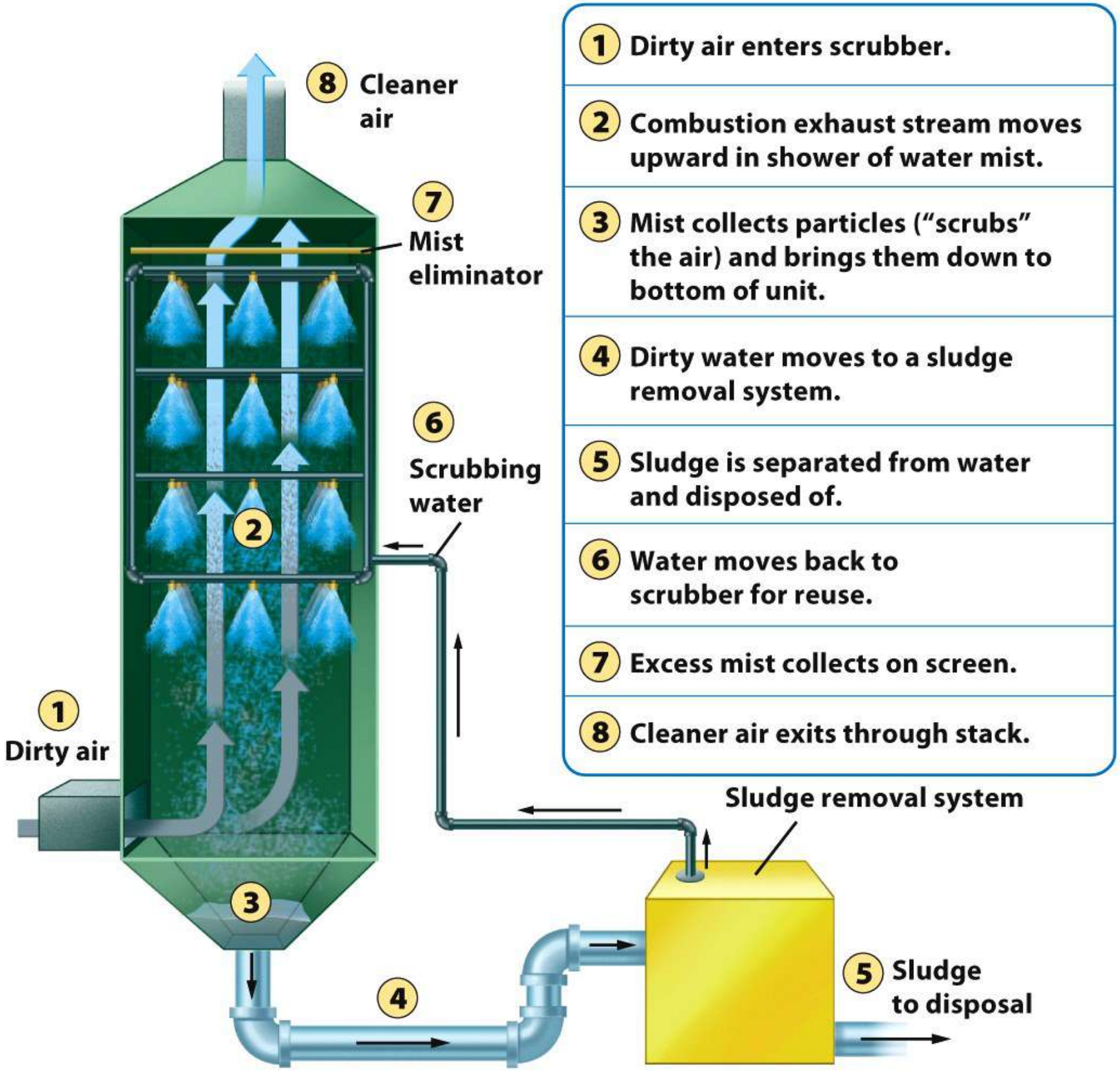


Figure 15.13
Environmental Science

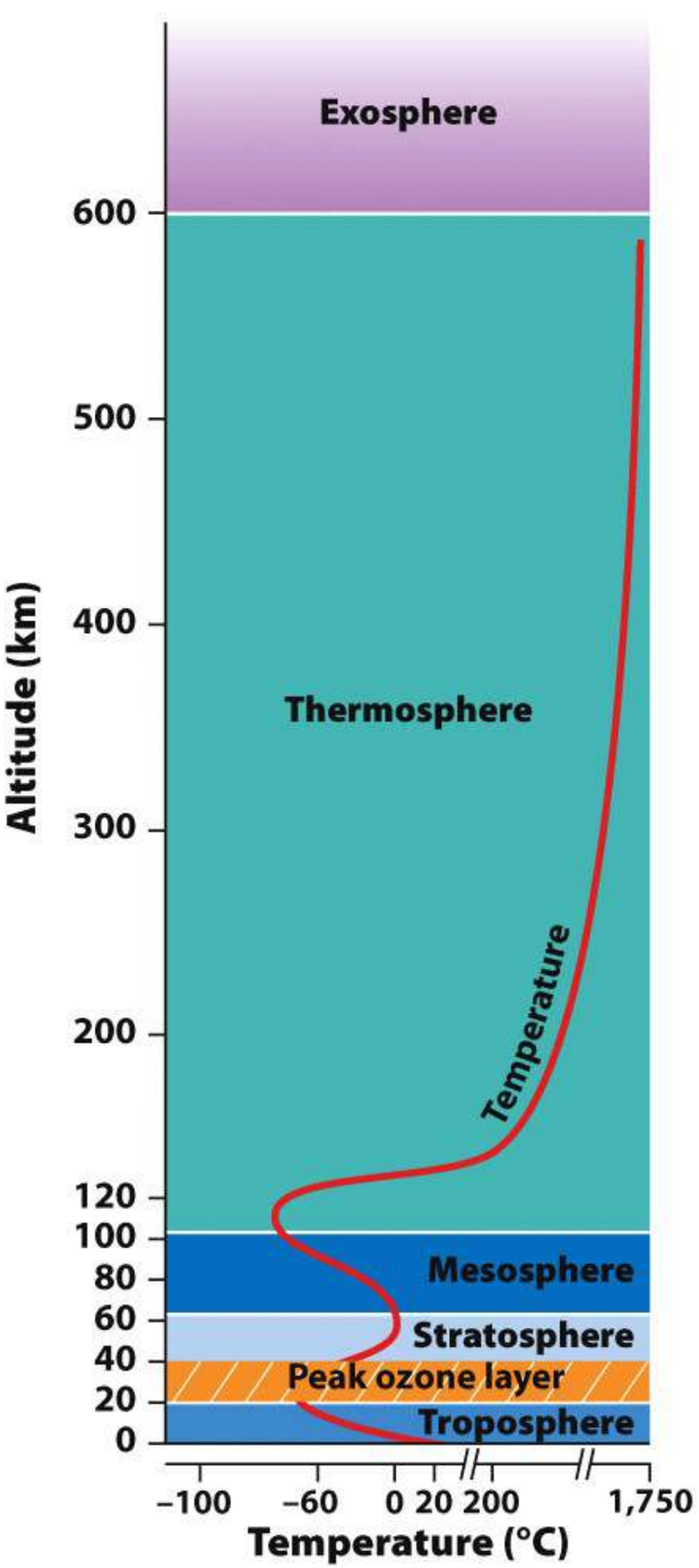


Figure 4.1
Environmental Science

Stratospheric Ozone

- The stratospheric ozone layer exists roughly 45-60 kilometers above the Earth.
- Ozone has the ability to absorb ultraviolet radiation and protect life on Earth.
- CFC

Formation and Breakdown of Ozone

- First, UV-C radiation breaks the bonds holding together the oxygen molecule) 2, leaving two free oxygen atoms:
  O_2 + UV-C -> 2O
- Sometimes the free oxygen atoms result in ozone:
  O_2 + O -> O_3
- Ozone is broken down into O_2 and free oxygen atoms when it absorbs both UV-C and UV-B ultraviolet light:
  O_3 + UV-B or UV-C -> O_2 + O

Anthropogenic Contributions to Ozone Destruction

- Certain chemicals can break down ozone, particularly chlorine.
- The major source of chlorine in the stratosphere is a compound known as chlorofluorocarbons (CFCs)
- CFCs are used in refrigeration and air conditioning, as propellants in aerosol cans and as “blowing agents” to inject air into foam products like Styrofoam, foam cushions.

Anthropogenic Contributions to Ozone Destruction

- When CFCs are released into the troposphere they make their way to the stratosphere.
- The ultraviolet radiation present has enough energy to break the bond connecting chlorine to the CFC molecule.
- which can then break apart the ozone molecules.

Anthropogenic Contributions to Ozone Destruction

- First, chlorine breaks ozone's bonds and pulls off one atom of oxygen, forming a chlorine monoxide molecule and O_2: $O_3 + Cl \rightarrow ClO + O_2$
- Next, a free oxygen atoms pulls the oxygen atom from ClO, liberating the chlorine and creating one oxygen molecule: $ClO + O \rightarrow Cl + O_2$
- One chlorine atom can catalyze the breakdown of as many as 100,000 ozone molecules before it leaves the stratosphere.

Depletion of the Ozone Layer

- Global Ozone concentrations had decreased by more than 10%.
- Depletion was greatest at the poles
- Decreased stratospheric ozone has increased the amount of UV-B radiation that reaches the surface of Earth.

Indoor Air Pollutants

Indoor Air Pollution - Zimbabwe

Figure 15.15
Environmental Science

- Wood, animal manure or coal used for cooking and heating in developing countries.
- Asbestos
- Carbon Monoxide
- Radon
- VOCs in home products

Sources of Indoor Air Pollution

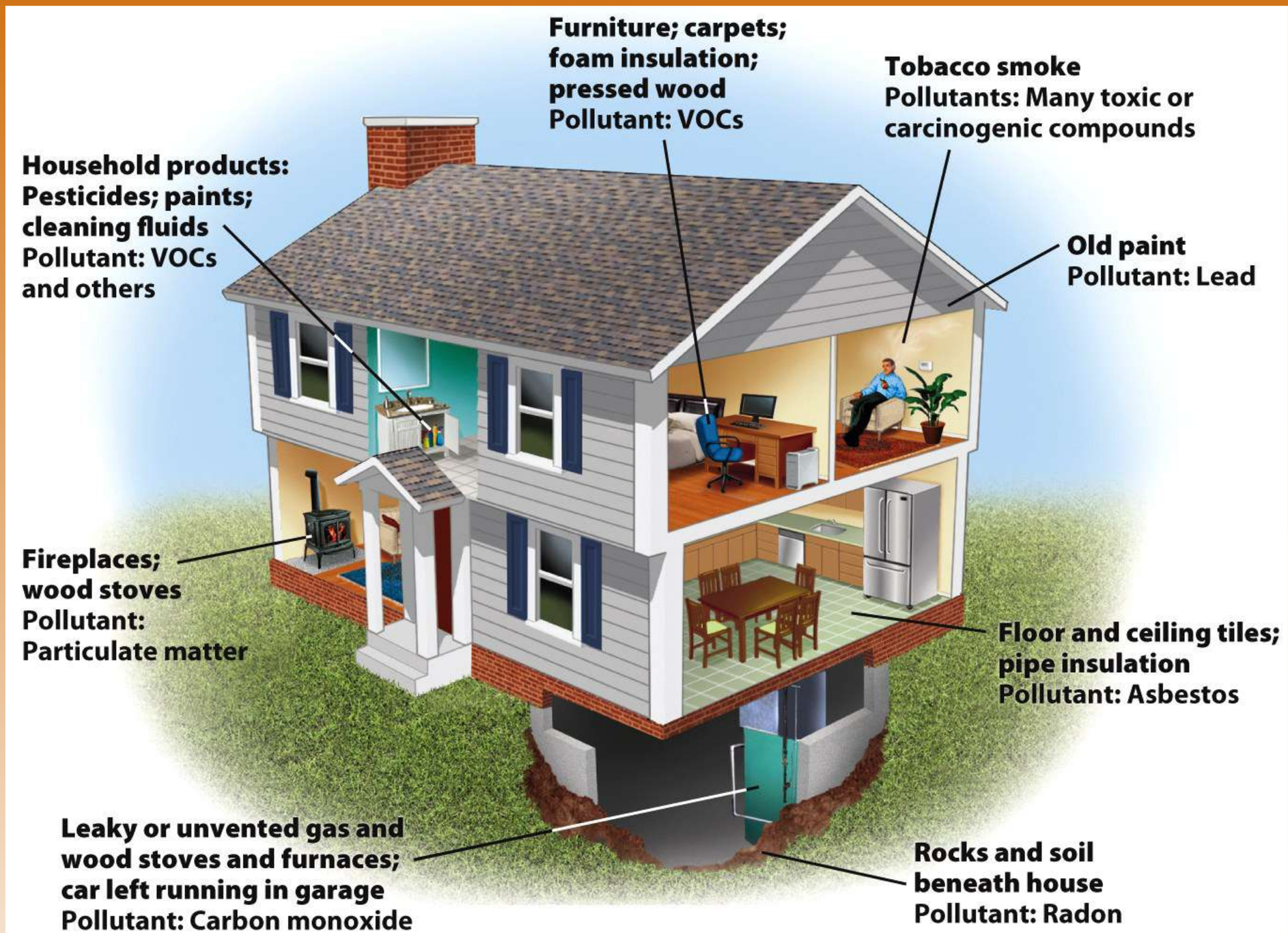


Figure 15.16
Environmental Science

Potential Radon exposure in United States

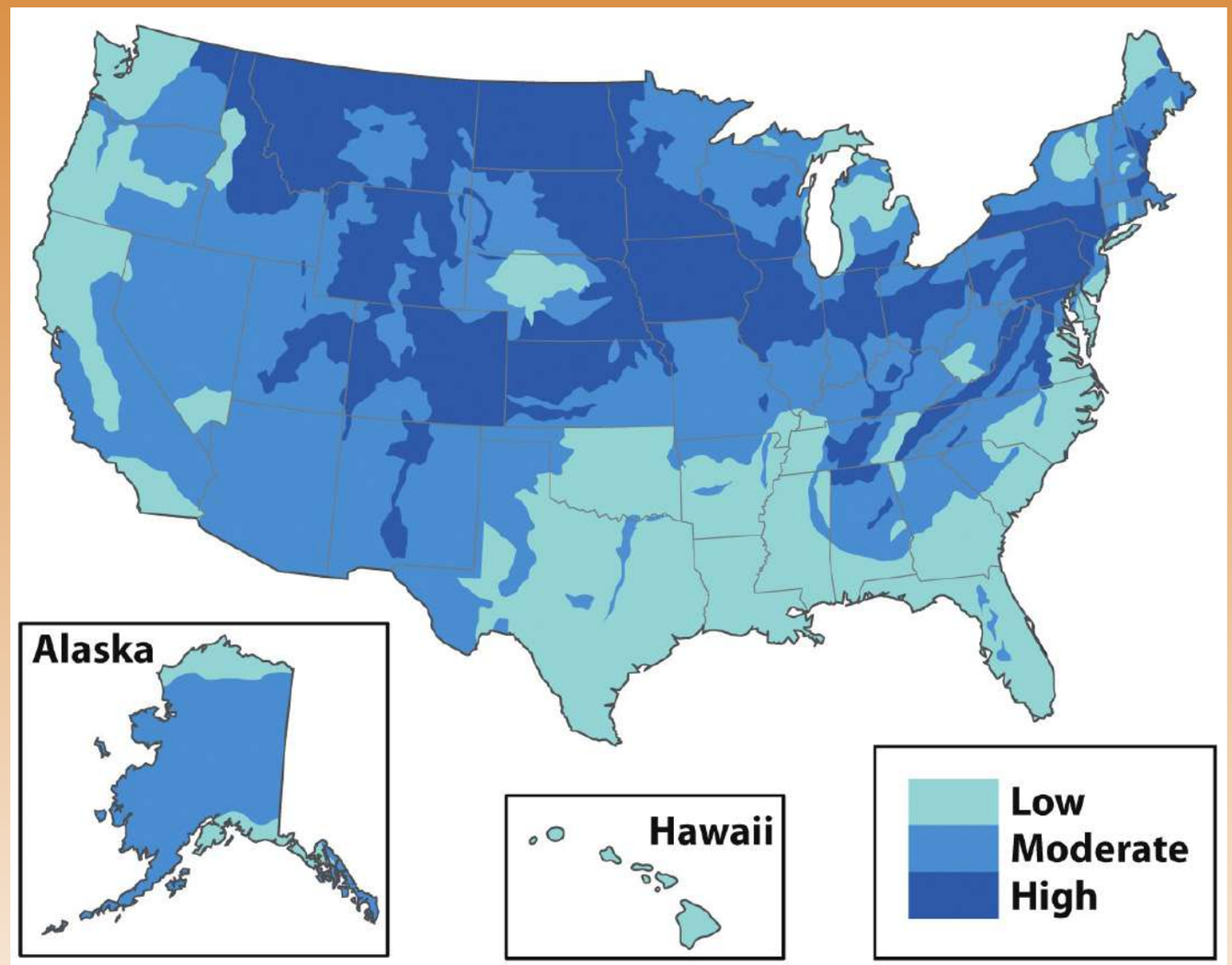


Figure 15.17
Environmental Science

Do the Math
Calculating Annual Sulfur Reductions

- Calculate the total percentage reduction and the annual percentage reduction of SO2 emissions.
- 23.5 million metric tons – 10.3 million metric tons -=13.2
- Divide the reduction by the original amount and multiply by 100 to obtain a percent reduction.
- The total reduction was 56 percent. To calculate the reduction per year divide 56 percent by the number of years from beginning to end:
- 2008 – 1982 = 26 years
- 56%/ 26 years = 2.2%/year

Working Toward Sustainability

- A New Cook Stove Design P. 430 ESBK