Selamat datang di kota polusi.
Rawat dan jaga asisi kendaraan Anda secara teratur.
Atmosphere as a Resource

- Atmospheric Composition
  - Nitrogen 78.08%
  - Oxygen 20.95%
  - Argon 0.93%
  - Carbon dioxide 0.04%

- Ecosystem services
  - Blocks UV radiation (stratosphere)
  - Moderates the climate (troposphere)
  - Redistributes water in the hydrologic cycle (troposphere)
Structure of Atmosphere

- The atmosphere’s innermost layer (troposphere) is made up mostly of nitrogen and oxygen, with smaller amounts of water vapor and CO2.

- Ozone in the atmosphere’s second layer (stratosphere) filters out most of the sun’s UV radiation that is harmful to us and most other species.
The Atmosphere’s Composition

- Nitrogen (N₂): 78.08%
- Oxygen (O₂): 20.95%
- Argon (Ar): 0.93%
- Neon (Ne): 0.0018%
- Helium (He): 0.0005%
- Hydrogen (H₂): trace
- Xenon (Xe): trace

Variable gases
- Water vapor (H₂O): 0–4%
- Carbon dioxide (CO₂): 0.038%
- Methane (CH₄): 0.00017%
- Nitrous oxide (N₂O): trace
- Ozone (O₃): trace
- Chlorofluorocarbons (CFCs): trace
Pollution

- Any quantity of pollutants that is harmful to human health or the environment
- Often byproducts of essential activities:
  - Crops
  - Making homes
  - Energy
  - Transportation
Air Pollution

- Natural causes
  - Human activities can exacerbate the problem
  - Dust storms from unsustainable grazing and farming
- Volcanic Eruptions
  - Release sulfur dioxide which can react with water and oxygen and condense into fine droplets called aerosols
  - Aerosols reflect sunlight back into space and cool the atmosphere
- Burning vegetation
  - 150 million acres of forest and grasslands are burned in a typical year
Air Pollution - Terminology

- **Air Pollution**
  - Chemicals added to the atmosphere by natural events or human activities in high enough concentrations to be harmful
- Two categories
  - **Primary Air Pollutant**
    - Harmful substance emitted directly into the atmosphere
  - **Secondary Air Pollutant**
    - Harmful substance formed in the atmosphere when a primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants
Sources of Pollution

- Agriculture - Fertilizers, animal wastes, etc.
- Municipal Waste - Sewage, fertilizers, dumping into drainage ditches, etc.
- Industrial Waste - Chemicals left over from manufacturing, waste products, etc.
- Transportation - burning of fossil fuels
Major Classes of Air Pollutants

- Particulate Material
- Nitrogen Oxides
- Sulfur Oxides
- Carbon Oxides
- Hydrocarbons
- Ozone
## Table 19.1  Major Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Composition</th>
<th>Primary or Secondary</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Particulate Matter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>Variable</td>
<td>Primary</td>
<td>Solid particles</td>
</tr>
<tr>
<td>Lead</td>
<td>Pb</td>
<td>Primary</td>
<td>Solid particles</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>H₂SO₄</td>
<td>Secondary</td>
<td>Liquid droplets</td>
</tr>
<tr>
<td><strong>Nitrogen Oxides</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>NO₂</td>
<td>Primary</td>
<td>Reddish-brown gas</td>
</tr>
<tr>
<td><strong>Sulfur Oxides</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>SO₂</td>
<td>Primary</td>
<td>Colorless gas with strong odor</td>
</tr>
<tr>
<td><strong>Carbon Oxides</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>CO</td>
<td>Primary</td>
<td>Colorless, odorless gas</td>
</tr>
<tr>
<td>Carbon dioxide*</td>
<td>CO₂</td>
<td>Primary</td>
<td>Colorless, odorless gas</td>
</tr>
<tr>
<td><strong>Hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane</td>
<td>CH₄</td>
<td>Primary</td>
<td>Colorless, odorless gas</td>
</tr>
<tr>
<td>Benzene</td>
<td>C₆H₆</td>
<td>Primary</td>
<td>Liquid with sweet smell</td>
</tr>
<tr>
<td><strong>Ozone</strong></td>
<td></td>
<td>Secondary</td>
<td>Pale-blue gas with acrid odor</td>
</tr>
<tr>
<td><strong>Air Toxics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl₂</td>
<td>Primary</td>
<td>Yellow-green gas</td>
</tr>
</tbody>
</table>

*Discussed in Chapter 20.

Source: Environmental Protection Agency. Compiled by authors.

© 2012 John Wiley & Sons, Inc. All rights reserved.
(a) Primary Pollutants

- Carbon monoxide: 48%
- Sulfur oxides: 16%
- Nitrogen oxides: 16%
- Volatile organic compounds: 15%
- Particulate matter: 5%

(b) Primary Sources

- Transportation: 45%
- Fuel combustion in stationary sources: 29%
- Industrial processes: 16%
- Miscellaneous: 7%
- Solid waste disposal: 2%
Particulate Material

◦ Primary pollutant
◦ Thousands of different solid or liquid particles suspended in air
  ◦ Includes: soil particles, soot, lead, asbestos, sea salt, and sulfuric acid droplets
◦ Dangerous
  ◦ May contain materials with toxic/carcinogenic effects
  ◦ Small particles can become lodged in lungs
Particulate Material

- **Lead (Pb)** = in gasoline and industrial metal smelting
  - Primary pollutant
  - Bioaccumulates and damages the nervous system
  - Banned in gasoline in developed, but not in developing countries
    - What does this mean about our air?
Nitrogen Oxides

- Nitrogen Oxides (NO$_2$ or NO$_x$)
- Reddish brown gas
- Primary pollutant
- They’re released by burning fuels.
  - When nitrogen and oxygen gas react at the high-combustion temperatures in automobile engines and coal-burning plants
  - Greenhouse gases that cause difficulty breathing
  - Vehicles, industrial combustion, electrical utilities
  - Contribute to smog and acid precipitation
Sulfur Oxides

- Sulfur Oxides (SO$_2$ or SO$_x$)
  - Primary pollutant
  - Gases produced by the chemical interactions between sulfur and oxygen
  - Coal emissions from electricity generation, industry
  - Causes acid precipitation
  - 1/3 comes from natural resources as part of the sulfur cycle
Carbon Oxides

- Carbon Oxides (CO and CO$_2$): greenhouse gas
- Primary pollutants

**Carbon dioxide (CO$_2$)**
- 93% is a result from the natural carbon cycle.
- 7% comes from burning fossil fuels and clearing forests/grasslands
- Associated with climate change
Carbon Oxides

- **Carbon monoxide (CO)** = colorless, odorless gas
  - Produced primarily by incomplete combustion of fuel
  - From vehicles and engines, industry, waste combustion, residential wood burning
  - Poses risk to humans and animals, even in small concentrations
  - It may cause death and confusion. Reacts with hemoglobin in red blood cells and reduces the ability of blood to transport oxygen
Hydrocarbons

- Hydrocarbons
  - Primary pollutants
  - Diverse group of organic compounds that contain only hydrogen and carbon (ex: CH₄ - methane)
  - Some are related to photochemical smog and greenhouse gases
  - VOC’s consist of hydrocarbons
Volatile Organic Compounds (VOC’s)

- Carbon containing chemicals used in and emitted by vehicle engines and solvents and industrial processes
- Found in industrial solvents, dry cleaning fluids, components of gasoline, plastics, and drugs
- These may cause cancer. They are released by burning hydrocarbons (benzene, isoprene, methane, etc.)
- Contribute to smog and tropospheric ozone
VOCs

- **Examples**
  - Methane- (CH$_4$) the primary component of natural gas
  - Propane (C$_3$H$_8$) - used as portable fuel
  - Butane- (C$_4$H$_{10}$) found in lighters
  - Octane- (C$_8$H$_{18}$) component of gasoline

- **Natural sources:**
  - Isoprene and terpene from plants
Ozone

- Ozone- Secondary Pollutant
- Good up high, bad nearby
- **Tropospheric Ozone (bad)**
  - Man-made pollutant in the lower atmosphere
  - Secondary air pollutant
  - Component of photochemical smog
- **Stratospheric Ozone (good)**
  - Essential component that screens out UV radiation in the upper atmosphere
  - Man- made pollutants (ex: CFCs) can destroy it
Formation of Tropospheric Ozone $O_3$

- $NO_2$ splits (by suns E) to form NO and O
- O binds with $O_2$ to form $O_3$
- Causes $O_3$ to accumulate
Pollutants "bake" together in direct sunlight forming ozone.
Ozone Damage to Grape Leaves

TED SPIEGEL/National Geographic Image Collection

TED SPIEGEL/National Geographic Image Collection
Sources of Outdoor Air Pollution

- Two main sources
  - Transportation
  - Industry
- Intentional forest fires is also high
U.S. air pollution

- In 2008, the U.S. emitted 123 million tons of the six monitored pollutants

The average U.S. driver emits 6 metric tons of CO$_2$/yr as well as other pollutants!
Urban Air Pollution

- Photochemical Smog (ex: Los Angeles below)
  - Brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons/VOCs
  - Car emissions reacting with sunlight
  - May cause asthma and emphysema
Sunlight plus Cars Equals Photochemical Smog

- Mexico City is one of the many cities in sunny, warm, dry climates with many motor vehicles that suffer from photochemical smog.
Formation of Photochemical Smog

**Photochemical smog**
- Nitric acid (HNO₃)
- PANs (Peroxyacyl nitrates)
- Formaldehyde and other aldehydes
- Ozone (O₃)

**Reactions in the atmosphere**
- Nitrogen dioxide (NO₂) + Water (H₂O)
- NO + Oxygen atom (O) + O + HC
- HC + O
- Oxygen gas (O₂) + O (in presence of HC and NO₃)

**Source of pollutants**
- Nitric oxide (NO)
- Carbon dioxide (CO₂)
- Hydrocarbons (HC)

© 2012 John Wiley & Sons, Inc. All rights reserved.
Sources of Smog in Los Angeles

- Consumer products and homes: 6%
- Aircraft, ships, and trains: 18%
- Industries (manufacturing, oil refineries, and power plants): 23%
- Trucks, buses, and passenger vehicles: 53%

© 2012 John Wiley & Sons, Inc. All rights reserved.
Industrial Smog

- Industrial smog is a mixture of sulfur dioxide, droplets of sulfuric acid, and a variety of suspended solid particles emitted mostly by burning coal.
- In most developed countries where coal and heavy oil is burned, industrial smog is not a problem due to reasonably good pollution control or with tall smokestacks that transfer the pollutant to rural areas.
Industrial vs. Photochemical smog

Industrial smog

- Sulfur (S) in coal and oil
- Oxygen (O₂)
- Burning
- Sulfur dioxide (SO₂)
- Oxygen (O₂)
- Burning
- Sulfur trioxide (SO₃)
- Water vapor (H₂O)
- Sulfuric acid (H₂SO₄)
  - Ammonia (NH₃)
  - Ammonium sulfate ((NH₄)₂SO₄)

(a) Burning sulfur-rich oil or coal without adequate pollution control technologies

Photochemical smog

- Nitrogen (N₂)
- Oxygen (O₂)
- Burning
- Nitric oxide (NO)
- Oxygen (O₂)
- Nitrogen dioxide (NO₂)
- UV radiation
  - Water vapor (H₂O)
  - Hydrocarbons
- Nitric oxide (NO)
- Nitric oxide (NO)
  - Oxygen atom (O)
  - Nitric acid (HNO₃)
- Oxygen (O₂)
- Ozone (O₃)
- Acid rain
- Various pollutants
- Volatile organic compounds (VOCs)
- Peroxyacyl nitrates (PANs)

(a) Formation of photochemical smog

© 2011 Pearson Education, Inc.
Thermal Inversions

- Weather and topography affect air pollution
- Normal air circulation patterns prevent toxic pollutants from increasing to dangerous levels near ground
  - Recall as hot air rises (as the sun warms up the earth), cool air moves in its place—this helps dilute and disperse pollutants
- Thermal inversion = a layer of cool air occurs beneath warm air
Thermal Inversions

- During thermal or temperature inversions, polluting gases and PMs remain trapped in high concentrations closest to the ground.
- Cities located in valleys, near the coast, or on the leeward side (the side toward which the wind blows) of mountains are prime candidates for thermal inversion.
- Warm air sandwiched between cool air.
- Los Angeles.
Effects of Air Pollution

- Low level exposure
  - Irritates eyes
  - Causes inflammation of respiratory tract
  - Can develop into chronic respiratory diseases

### Table 19.2: Health Effects of Several Major Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Source</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>Industries, electric power plants, motor vehicles, construction, agriculture</td>
<td>Aggravates respiratory illnesses; long-term exposure may cause increased incidence of chronic conditions such as bronchitis; linked to heart disease; suppresses immune system; some particles, such as heavy metals and organic chemicals, may cause cancer or other tissue damage</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>Motor vehicles, industries, heavily fertilized farmland</td>
<td>Irritate respiratory tract; aggravate respiratory conditions such as asthma and chronic bronchitis</td>
</tr>
<tr>
<td>Sulfur oxides</td>
<td>Electric power plants and other industries</td>
<td>Irritate respiratory tract; same effects as particulates</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Motor vehicles, industries, fireplaces</td>
<td>Reduces blood’s ability to transport oxygen; headache and fatigue at lower levels; mental impairment or death at high levels</td>
</tr>
<tr>
<td>Ozone</td>
<td>Formed in atmosphere (secondary air pollutant)</td>
<td>Irritates eyes; irritates respiratory tract; produces chest discomfort; aggravates respiratory conditions such as asthma and chronic bronchitis</td>
</tr>
</tbody>
</table>
Children and Air Pollution

- Greater health threat to children than adults
  - Air pollution can restrict lung development
  - Children breath more often than adults
- Children who live in high ozone areas are more likely to develop asthma
Core Case Study: When Is a Lichen Like a Canary?

- Lichens can warn us of bad air because they absorb it as a source of nourishment.
Some lichen species are sensitive to specific air-polluting chemicals.

After Chernobyl (If you don’t know what this is, google it and know it!), more than 70,000 reindeer had to be killed because they ate highly radioactive lichens.

Because lichens are widespread, long-lived, and anchored in place, they can help track pollution to its source.
<table>
<thead>
<tr>
<th>Urban Air Quality</th>
</tr>
</thead>
</table>

**Table 19.3  U.S. Urban Areas with the Worst Air Quality in 1999 (Ozone Nonattainment Areas), and Conditions in the Same Locations in 2009.**

<table>
<thead>
<tr>
<th>Area</th>
<th>1999</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles South Coast Air Basin, Calif.</td>
<td>Extreme</td>
<td>Severe</td>
</tr>
<tr>
<td>Chicago, Gary, and Lake County, Ill-Ind.</td>
<td>Very severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Houston, Galveston, and Brazoria, Texas</td>
<td>Very severe</td>
<td>Severe</td>
</tr>
<tr>
<td>Milwaukee and Racine, Wisc.</td>
<td>Very severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>New York City, northern N.J., and Long</td>
<td>Very severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Island, N.Y.-N.J.-Connecticut</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltimore, Maryland</td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Philadelphia, Wilmington, Trenton, Penn.</td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>New Jersey–Delaware–Maryland</td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sacramento, Calif.</td>
<td>Severe</td>
<td>No longer listed</td>
</tr>
<tr>
<td>San Joaquin Valley, Calif.</td>
<td>Severe</td>
<td>No longer listed</td>
</tr>
<tr>
<td>Ventura County (between Santa Barbara and Los Angeles), Calif.</td>
<td></td>
<td>No longer listed</td>
</tr>
</tbody>
</table>
Acid Deposition

- Sulfur dioxide and nitrogen dioxide emissions react with water vapor in the atmosphere and form acids that return to the surface as either dry or wet deposition.
- pH scale
How Acid Deposition Develops

Wind

SO₂ & NOₓ

Conversion to acids:
sulfuric acid (H₂SO₄)
nitric acid (HNO₃)
nitrous acid (HNO₂)

(NO)

Power plant and industrial plumes

Mobile emissions

Dry acid deposition

Wet acid deposition (droplets of H₂SO₄, HNO₃, and HNO₂ dissolved in rain and snow)

Lakes become acidic

Surface runoff

© 2012 John Wiley & Sons, Inc. All rights reserved.
Acid Rain

- **Anthropogenic-**
  - Sulfuric and Nitric Acids created from burning fossil fuels

- **Effects in:**
  - **Aquatic systems-**
    - Changes pH of environment
    - Higher organisms die first
  - **Forests-**
    - Interactions with soils
      - When the soil pH dips to 5 or lower (from acid deposition), aluminum ions are dissolved into the water and become toxic to plants.
      - Aluminum ions cause a stunting of the root growth and prevent the roots from taking up calcium.
  - **Humans**
    - Artifacts, erosion of buildings

- **Natural-**
  - SO2 from volcanoes, sea spray and microbial processes
  - NO2 from lightening
Effects of Acid Deposition

- Declining Aquatic Animal Populations
- Thin-shelled eggs prevent bird reproduction
  - Calcium is unavailable in acidic soil
- Forest decline
  - (right) Black Forest in Germany
Windborne ammonia gas and particles of cultivated soil partially neutralize acids and form dry sulfate and nitrate salts.

Wet acid deposition (droplets of $H_2SO_4$ and $HNO_3$ dissolved in rain and snow)

Nitric oxide (NO)

Sulfur dioxide ($SO_2$) and NO

Dry acid deposition (sulfur dioxide gas and particles of sulfate and nitrate salts)

Ocean

Lakes in deep soil high in limestone are buffered

Lakes in shallow soil low in limestone become acidic

© 2007 Thomson Higher Education

Fig. 19-6, p. 448
ACID DEPOSITION

- pH measurements in relation to major coal-burning and industrial plants.

Figure 19-7
ACID DEPOSITION

- Acid deposition contributes to chronic respiratory disease and can leach toxic metals (such as lead and mercury) from soils and rocks into acidic lakes used as sources for drinking water.
ACID DEPOSITION

- Air pollution is one of several interacting stresses that can damage, weaken, or kill trees and pollute surface and groundwater.
Acid Deposition Solutions

**Prevention**
- Reduce air pollution by improving energy efficiency
- Reduce coal use
- Increase natural gas use
- Increase use of renewable energy resources
- Burn low-sulfur coal
- Remove SO\textsubscript{2} particulates & NO\textsubscript{x} from smokestack gases
- Remove NO\textsubscript{x} from motor vehicular exhaust
- Tax emissions of SO\textsubscript{2}

**Cleanup**
- Add lime to neutralize acidified lakes
- Add phosphate fertilizer to neutralize acidified lakes

© 2007 Thomson Higher Education

Fig. 19-10, p. 452
Air Pollution Around the World

- Air quality is deteriorating rapidly in developing countries
  - Developing countries have older cars
- Shenyang, China
  - Residents only see sunlight a few weeks each year
- 5 worst cities in world
  - Beijing, China; Mexico City, Mexico; Shanghai, China; Tehran, Iran; and Calcutta, India
Pollution in developing nations is high

More people own cars

Smog in Beijing surrounds an Olympic stadium
Case-In-Point Air Pollution in Beijing and Mexico City

- Beijing (left)
- Mexico City (right)
Long Distance Transport of Air Pollutants

Global Distillation Effect

1. Long-distance atmospheric transport occurs in part because evaporation exceeds deposition onto the land and ocean at low latitudes.

2. The more volatile the chemical, the farther it travels before being deposited onto the land and ocean.

3. Some chemicals move to higher latitudes by repeatedly evaporating and settling ("leapfrogging"), sometimes taking several decades before being permanently deposited.

© 2012 John Wiley & Sons, Inc. All rights reserved. Adapted from F. Wania, and D. Mackay, “Tracking the Distribution of Persistent Organic Pollutants,” Environmental Science and Technology, Vol. 30 (1996)
Controlling Air Pollution

- Smokestacks with **electrostatic precipitator** (right)
  - Electrode imparts negative charge on the air pollutants
  - Negatively charged pollutants are then attracted to positively charged walls- fall into collector
Controlling Air Pollution

- Smokestacks with **scrubbers** (right)
- Particulate material can also be controlled by proper excavating techniques
Scrubbers

Emissions not controlled - heavily polluted

Emissions controlled with scrubbers-only steam expelled

© 2012 John Wiley & Sons, Inc. All rights reserved.
The Clean Air Act

- Authorizes EPA to set limits on amount of specific air pollutants permitted

- **Focuses on 6 pollutants:**
  - lead, particulate matter, sulfur dioxide, carbon monoxide, nitrogen oxides, and ozone

- Act has led to decreases in air pollutants
  - Most dramatic is lead - decreased by 98% since 1970 (due to switch to unleaded gasoline)
The Clean Air Act

![Graph showing emissions reduction over time for various air pollutants (e.g., Carbon monoxide, Sulfur dioxide, Volatile organic compounds, Nitrogen oxides, Particulate matter (PM=2.5)).](image)

*Air Quality Planning and Standards, Office of Air and Radiation, EPA*
INDOOR AIR POLLUTION

- Indoor air pollution usually is a greater threat to human health than outdoor air pollution.
- According to the EPA, the four most dangerous indoor air pollutants in developed countries are:
  - Tobacco smoke.
  - Formaldehyde.
  - Radioactive radon-222 gas.
  - Very small fine and ultrafine particles.
Indoor Air Pollution

- Pollutants can be 5–100x greater than outdoors.
- Radon, cigarette smoke, carbon monoxide, nitrogen dioxide, formaldehyde, pesticides, lead, cleaning solvents, ozone, and asbestos.
Indoors Air Pollution

- Higher level of hazardous pollutants than outdoors
  - Types and quantity of household products
  - Buildings are well insulated
  - People spend most time indoors
Radon

- Naturally occurring radioactive gas found in some soil and rock.
- Seeps in homes and buildings sitting above such deposits.
- Long term exposure can cause lung cancer, especially among smokers.
Case Study: Radioactive Radon

Radon-222, a radioactive gas found in some soils and rocks, can seep into some houses and increase the risk of lung cancer.

Sources and paths of entry for indoor radon-222 gas.

Figure 19-13
Indoor Air Pollution - Radon
VOCs pollute indoor air

- The most diverse group of indoor air pollutants
  - Released by everything from plastics and oils to perfumes and paints
  - Most VOCs are released in very small amounts
- Unclear health implications due to low concentrations
- Formaldehyde leaking from pressed wood and insulation irritates mucous membranes and induces skin allergies
- Pesticides seep through floors and walls
  - Are brought in on shoe soles
Sources of indoor air pollution

- **Hot showers with chlorine-treated water**
  - Pollutant: Chloroform
  - Health risks: Nervous system damage

- **Old paint**
  - Pollutant: Lead
  - Health risks: Nervous system and organ damage

- **Fireplaces; wood stoves**
  - Pollutant: Particulate matter
  - Health risks: Respiratory problems, lung cancer

- **Pipe insulation; floor and ceiling tiles**
  - Pollutant: Asbestos
  - Health risks: Asbestosis

- **Unvented stoves and heaters**
  - Pollutant: Nitrogen oxides
  - Health risks: Respiratory problems

- **Pets**
  - Pollutant: Animal dander
  - Health risks: Allergies

- **Pesticides; paints; cleaning fluids**
  - Pollutants: VOCs and others
  - Health risks: Neural or organ damage, cancer

- **Rocks and soil beneath house**
  - Pollutant: Radon
  - Health risks: Lung cancer

- **Heating and cooling ducts**
  - Pollutants: Mold and bacteria
  - Health risks: Allergies, asthma, respiratory problems

- **Furniture; carpets; foam insulation; pressed wood**
  - Pollutant: Formaldehyde
  - Health risks: Respiratory irritation, cancer

- **Leaky or unvented gas and wood stoves and furnaces; car left running in garage**
  - Pollutant: Carbon monoxide
  - Health risks: Neural impairment, fatal at high doses

- **Gasoline**
  - Pollutant: VOCs
  - Health risks: Cancer

- **Tobacco smoke**
  - Pollutants: Many toxic or carcinogenic compounds
  - Health risks: Lung cancer, respiratory problems

- **Computers and office equipment**
  - Pollutant: VOCs
  - Health risks: Irritation, neural or organ damage, cancer
Chloroform

Benzo-a-pyrene

Styrene

Radon-222

Nitrogen Oxides

Para-dichlorobenzene

Tetrachloroethylene

Formaldehyde

Benzo-a-pyrene

Particulates

1, 1, 1-Trichloroethane

Formaldehyde

Tobacco Smoke

Methylene Chloride

Carbon Monoxide

Asbestos

Fig. 19-11, p. 453
INDOOR AIR POLLUTION

- Household dust mites that feed on human skin and dust, live in materials such as bedding and furniture fabrics.
- Fungi, mold, mildew, airborne bacteria cause allergies, asthma, other respiratory ailments, and diseases.
Building-related illness = a sickness produced by indoor pollution

Sick building syndrome = a sickness produced by indoor pollution with general and nonspecific symptoms

Reduced by using low-toxicity building materials and good ventilation
Indoor air pollution in the developing world

- Stems from burning wood, charcoal, dung, crop wastes with little to no ventilation
- Fuel burning pollution causes 1.6 million deaths/year
  - Soot and carbon monoxide
  - Pneumonia, bronchitis, lung cancer, allergies, cataracts, asthma, heart disease, etc.