Exercise and Air Pollution

Two Major Groups of Air Pollutants
- **Primary**
  - From a single source of pollution
  - CO, sulfur oxides, nitrogen oxides, hydrocarbons, particulates
- **Secondary**
  - Result from an interaction with the environment and a primary pollutant
  - Ozone, aldehydes, sulfuric acid, peroxyacetyl nitrate (PAN)

Effective Dose
- Damage is related to dosage
- \[ ED = \text{exposure time (min)} \times \text{concentration (ppm)} \times \text{ventilation (L/min)} \]
- ED also is affected by
  - Temp and humidity
  - Route of inspiration (nose or mouth)

Exercise and Air Pollution
- Exercise worsens the effect of air pollution
  - Increases V̇e
  - Increases mouth breathing
  - One 30-min training session is equivalent to 8 hr of sedentary living

Paths of Air Pollution
- Primarily affects the respiratory tract
  - Mucous membranes of the nose remove large particles and soluble gases
  - Smaller particles or low soluble gases reach deeper airways and lung tissue
  - Some can reach the alveoli and enter the blood
  - Some affect the eyes
  - Some cross the skin

Respiratory Effects
- Bronchoconstriction
- Reduced alveolar diffusing capacity
  - Inflammation
- Reduced O₂ transport
- Will lead to reduced exercise capacity
- Some people are more susceptible
  - Impaired immune function
  - People with pulmonary disease
  - People with cardiovascular disease
Outdoor Pollution
- 70% from fossil fuels
  - CO, sulfur and nitrogen oxides
  - Hydrocarbons, particles
- Most from automobiles and industry
- Severity depends on the environment
  - Winds
  - Hot and humid—promote photochemical reactivity
  - Cold—promotes heating fuel
- Geography and climatic inversion

Rural Air Pollution?
- Dust from plant or animal proteins, organic dusts
- Farmer's lung
  - Dust from moldy hay
  - Spores of bacteria
  - Hypersensitivity pneumonitis

Carbon Monoxide
- Most common pollutant in urban regions
  - Sources: cars, power plants, burning, industry
  - Notable indoor occurrences
    - Ice skating rink
    - Tunnels
    - Smokers side stream smoke
  - VO$_2$max ↓ directly ~ %CO
  - Critical level is ~4% HbCO

Carbon Monoxide Levels
- Levels are higher during morning and evening rushes
  - 4% smokers baseline levels
  - 5% HbCO in heavy traffic
  - 2%, earlier onset of angina in CAD
  - 6% arrhythmias in CAD patients
- Exercise in traffic for 30 min = equivalent of 10 cigarettes!

Sulfur Oxides (S$_2$O)
- Sources: sulfur containing fuels, sulfuric acid producing facilities
- Mainly SO$_2$ or acid sulfides
- Irritate the upper respiratory tract
- Nasal mucosa removes 99.9% of SO$_2$
- Threshold effect 1-3 ppm
- People with asthma are 5x as sensitive

Thermal Inversion
- A
  - Cooler air
  - Warmer air
  - Sandias

- B
  - Cooler air
  - Warmer air
  - Sandias

- CD
**Nitrogen Oxides (N\textsubscript{2}O)**
- **Sources:** power plants, cars, forest fires, trains, planes, volcanos, industry, burning
- **Soluble**—absorbed by the mucous lining of nasopharyngeal cavity to form nitrous and nitric acid
- **Can cause respiratory illness, reduced resistance to respiratory infection, bc in asthmatics**
- **200-4000 ppm NO\textsubscript{2} causes death**

**Particulants**
- **Sources:** dust, power plants, diesel trucks, industry, pollen, wood smoke, bacteria
- **Solid or liquid particles in air**
- **Associated with airway constriction**
- **Effect depends on size**
  - $<3\mu m$, reach alveoli
  - 3-5 $\mu m$, upper respiratory tract
  - $>5\mu m$, removed by coughing, sneezing

**Aerosols**
- **Mixtures of fluid and particles**
- **May cause airway irritation**
  - Sulfates
  - Sulfuric acids
  - Nitrate aerosols
  - Aldehydes

**Ozone (O\textsubscript{3})**
- **Secondary pollutant**
  - Sunlight electrical arcs and oxygen
- **Absorbed by mucous membranes**
- **Cause throat irritation, cough, nausea, headaches, chest pain**
- **Asthmatics especially sensitive**
- **0.3 ppm levels can cause pulmonary dysfn**
- **0.08 ppm for 7 hrs can cause problems**
  - Levels fairly common
- **Adaptation with repeated exposure**

**Peroxyacetyl Nitrate (PAN)**
- **Secondary pollutant**
- **Nitrogen oxides + organic compounds**
- **Eye irritation at levels $<0.27$ ppm**

**Indoor Pollution**
- **Major indoor pollutants**
  - Soil gases: radon, methane, hydrogen sulfide, organic compounds from building materials
  - Combustion products: CO, nitrogen dioxide, heating appliances
  - Formaldehyde: from lumber, adhesives, foam insulation
- **Most serious are formaldehyde, tobacco smoke**
Interactions

- Air has many pollutants
  - Additive effects: CO and PAN; O3 and SO2; SO2 and NO2
  - Additive effects: Heat stress and CO, PAN and O3
  - Synergistic effects: Humidity and dust mites, molds, fungi in indoor environments; dry air and SO2
  - Additive effects: CO and altitude

Prevention

- Avoidance of exposure
  - Indoors
    - Fireplaces, humidity 30-70%, cleaners and building materials
  - Outdoors
    - Timing of exercise
      - CO—avoid traffic
      - O3—avoid peak sunlight
    - PSI standards (pollutant standards index)

PSI Values

<table>
<thead>
<tr>
<th>PSI Score</th>
<th>PSI Color</th>
<th>General Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50</td>
<td>Green</td>
<td>None</td>
</tr>
<tr>
<td>51-100</td>
<td>Yellow</td>
<td>Some respiratory irritation, headache, fatigue, nausea, weakness, dizziness</td>
</tr>
<tr>
<td>101-200</td>
<td>Orange</td>
<td>Significant respiratory irritation, coughing, shortness of breath, throat irritation</td>
</tr>
<tr>
<td>&gt;200</td>
<td>Red</td>
<td>Health effects may be severe and life-threatening</td>
</tr>
</tbody>
</table>

EPA PSI

- Converts pollutant concentration to a number on a scale 0-500
- 100 = threshold under Clean Air Act above which indicates pollution in an unhealthy range
- Threshold for acute health effects (24 hr), rather than chronic

EPA Air Quality Standards

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Time Period</th>
<th>Standard Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>8 hr</td>
<td>9 ppm</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>1 hr</td>
<td>19 ppm</td>
</tr>
<tr>
<td>Ozone</td>
<td>1 hr</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>8 hr</td>
<td>19 ppb</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>8 hr</td>
<td>12 ppb</td>
</tr>
<tr>
<td>Sodium</td>
<td>24 hr</td>
<td>0.05 mg/m³</td>
</tr>
<tr>
<td>Chloride</td>
<td>24 hr</td>
<td>0.05 mg/m³</td>
</tr>
<tr>
<td>Particulate (PM 2.5)</td>
<td>24 hr</td>
<td>15 μg/m³</td>
</tr>
<tr>
<td>Particulate (PM 10)</td>
<td>24 hr</td>
<td>100 μg/m³</td>
</tr>
</tbody>
</table>

Room ventilation standards

- Use CO2 levels as an indicator for sufficient ventilation
  - Outdoor limit: 1000 ppm (0.1%)
  - Indoor limit: 350 ppm minimum, 650 ppm better (0.06%)
Infectious Disease
- Bacterial or virus infections that spread from person to person
- Viral mutations
  - In people (most commonly in malnourished people with weak immune function) ebola virus in Africa
  - In animals, then transfer to humans

1918 Influenza Pandemic
- New influenza virus raced around the world in 4 months: unusually virulent
  - Chinese laborers-military camps-troop ships—Europe. As many influenza deaths in American soldiers as war deaths.
  - 50% of world population infected
  - Quarantines, closed schools and businesses
  - 40 to 50 million deaths between 1918 and 1920 (3% of world population)
  - Healthy young adults had highest fatalities

H5N1 Bird Flu Virus
- 1997:H5N1 virus is discovered in Hong Kong
- 2004: N5N1 is transmitted from birds to humans in Thailand and Vietnam
- 1997-2004: 126 people contract N5N1, 64 died