The Atmosphere

- This is our protective blanket of gasses.

- 78% Nitrogen ($N_2$)
- 21% Oxygen ($O_2$)
- Proportionally small amounts of carbon dioxide, water vapor and other trace substances
Atmospheric Gases

Clean, dry air is a mixture of molecules of three important gases. 

<table>
<thead>
<tr>
<th>Clean, dry air</th>
<th>Percent</th>
<th>Chemical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen gas</td>
<td>78.08%</td>
<td>$N_2$</td>
<td>$\equiv N$</td>
</tr>
<tr>
<td>Oxygen gas</td>
<td>20.95%</td>
<td>$O_2$</td>
<td>$O=O$</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>0.035%</td>
<td>$CO_2$</td>
<td>$O=C=O$</td>
</tr>
</tbody>
</table>

$^a$The remaining 0.94 percent is composed of inert gases, which have no biological importance.
The Atmosphere - Layers

- **Troposphere**
  - Layer in which we live
  - Most weather occurs here
    - Clouds form here contributing to the albedo effect
  - 90% of the gases are here
  - 78% nitrogen, 21% oxygen
  - Temperature decreases with altitude until the next layer is reached
The Atmosphere - Layers

- **Stratosphere**
  - 6-31 miles in altitude
  - Calm
  - Air traffic due to lack of weather
  - Temperature increases with altitude
  - Ozone layer (oxygen is converted to $O_3$ by lightning and/or sunlight)
  - 99% of ultraviolet radiation (especially UV-B) is absorbed by the stratosphere
Ozone Layer

• Present in the stratosphere
• Absorbs UV radiation (99%)
• Comprised of a high concentration of $O_3$ molecules.
  – Oxygen exists in 3 forms in the atmosphere: $O_3$, $O_2$, and O.
  – Ozone is being continuously formed and decomposed due to the energy from UV rays.

$$O_3 + \text{UV} \rightarrow O_2 + O \rightarrow O_3$$
Ozone

- Ozone is $O_3$
- Naturally occurring in the stratosphere.
- The absorption of energy from UV rays causes the formation and deformation of $O_3$.
- Without anthropogenic inputs the system is in equilibrium

$$O_3 \leftrightarrow O_2 + O$$
Ozone

Stratospheric Ozone
• Naturally occurring.
• Beneficial to life on Earth
• Creates a protective layer that absorbs 99% of UV radiation in sunlight

Tropospheric Ozone
• Also called ground-level ozone
• Anthropogenic
• Does NOT migrate to the atmosphere
• Secondary Air pollutant
• Respiratory irritant, eye irritant, damages plants
Destruction of Atmospheric Ozone

• The group of molecules that are in this category are often referred to as ODS (Ozone Depleting Substances)

• Anthropogenic sources:
  – CFCs
  – Halocarbons/Halons
    • Used in fire retardants
    • Foam-blowing insulation

• 1 chlorine can destroy 100,000 ozone molecules
CFCs

- Chlorofluorocarbon
- Trademark name is Freon
- CFCs have stable structures which allow them to migrate through the troposphere
- They are broken down when exposed to strong UV radiation
- Used in
  - Refrigerants
  - Propellants/aerosols
  - Gas blown plastics (Styrofoam)
  - Pesticides
  - Flame retardants
Summary of CFC Reactions

$\text{CCl}_3\text{F} + \text{UV} \rightarrow \text{Cl} + \text{CCl}_2\text{F}$

$\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$

$\text{ClO} + 0 \rightarrow \text{Cl} + \text{O}_2$

Repeated many times
Video of Ozone Depletion

- https://www.youtube.com/watch?v=V7eDjqJ7vsY
Thinning ozone
Effects of Thinning Ozone Layer

Environmental Effects
• Greater UV radiation damages photosynthetic organisms (especially phytoplankton) decreasing primary productivity
• Sunburns animals
• Cataracts/blindness in animals

Human Health Effects
• Sunburn/skin cancer
• Cataracts (eye damage)
• Wrinkles
• Decreased immune response
Pollution Management

- Recycling refrigerants
- Finding alternatives to gas-blown plastics, halogenated pesticides, propellants and aerosols
- Developing non-propellant alternatives
Montreal Protocol

- International treaty to protect the ozone layer by phasing out materials believed to cause the depletion of stratospheric ozone
- Has been VERY successful. Ozone layer is showing signs of recovery
- Bans CFCs and halons
- Includes several groups of substances, all of them including chlorine or bromine.