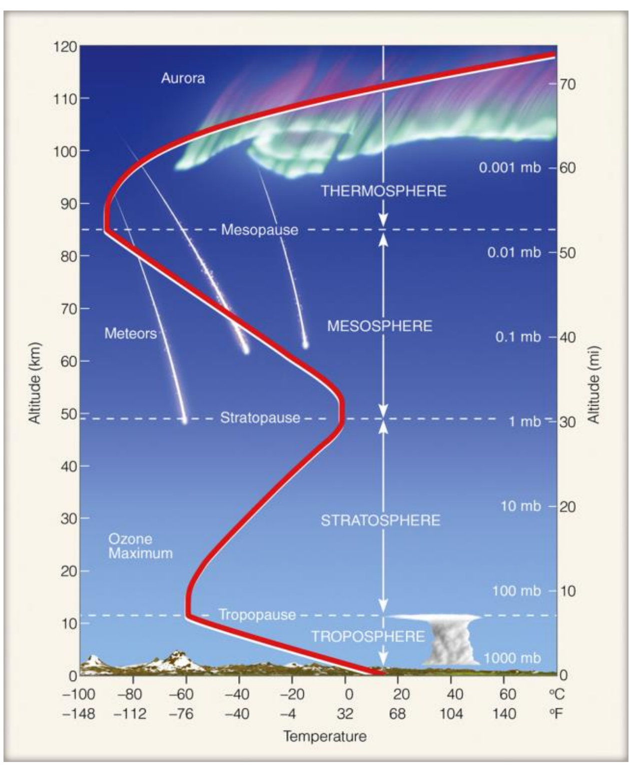
TEACHER BACKGROUND:
EARTH'S ATMOSPHERE

The atmosphere is the thin envelope of gas molecules surrounding the Earth; it is held down by Earth's gravitational pull. The atmosphere is concentrated at the Earth's surface and rapidly thins as you move upward, blending with space at about 100 miles above sea level. The atmosphere is actually very thin compared to the size of the earth. Its thickness can be compared to a piece of paper laid over a beach ball or the skin of an apple. The heat trapping ability it has helps to keep the Earth warm enough for life, and it also protects the Earth from harmful solar radiation and cosmic rays.



Layers of the Atmosphere

While there are no exact boundaries within the atmosphere, it is divided into layers based on temperature and pressure. The very lowest layer, which contains 90% of the atmosphere's mass, is called the ***troposphere.*** This is also where all living things are found and where all weather occurs. Airplanes fly at the very top of the troposphere, so they can fly over the weather, which causes turbulence. The jet stream, a fast moving region of wind in the upper troposphere has been clocked at over 300 miles per hour! While temperatures at the bottom of the troposphere are nice and hospitable for life, temperatures at the top about -60°F! The troposphere is also the thinnest layer, only about 10 miles high.

The second layer up from the ground is the ***stratosphere***. This layer extends from about 10-30 miles, and unlike the troposphere, it increases in temperature with elevation. It starts out from about -60°F at the bottom to about 32°F, at the top). This is because ozone molecules form here and absorb the warm ultraviolet radiation from the sun.

The third and middle layer is the ***mesosphere***. This layer extends from 30-50 miles in altitude, and unlike the stratosphere below, it absorbs very little solar radiation. This layer is incredibly cold, going from freezing at the bottom to about -130°F at the top.

The next layer up, the ***thermosphere***, is the largest layer, extending from 50-300 miles. Satellites orbit Earth here, and this layer actually increases in temperature with increasing altitude. The ***ionosphere*** is a sub-layer found at the top of the mesosphere and the bottom of the thermosphere and gets it because it is ion-rich. This region is a special place in the sky because this is where displays of light in the sky called ***auroras*** occur.

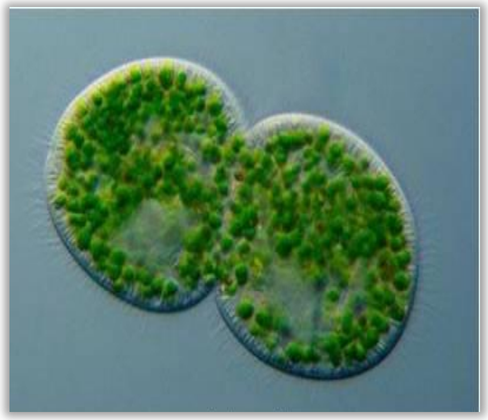
The final layer is the called the ***exosphere*** because it is on the outside like an exoskeleton. This layer begins at about 300 miles from the ground but, as mentioned before, slowly fades into space, so it's hard to tell exactly where it ends.

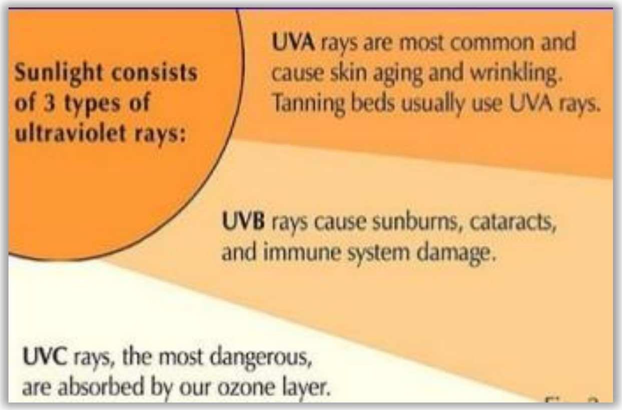
Origin of the Atmosphere

Scientists believe that Earth was formed about 5 billion years ago. In the first, 500 million years a dense atmosphere emerged from the vapor and gases expelled during volcanic degassing of the planet's interior.

These gases probably consisted of hydrogen (H_2), water vapor, methane (CH_4), and carbon oxides. Prior to 3.5 billion years ago the atmosphere probably consisted of carbon dioxide (CO_2), water (H_2O), nitrogen (N_2) and hydrogen. The most important feature of the ancient atmosphere was the absence of free oxygen. Evidence of an oxygen-free atmosphere is hidden in early rock formations that contain many elements, such as iron and uranium.

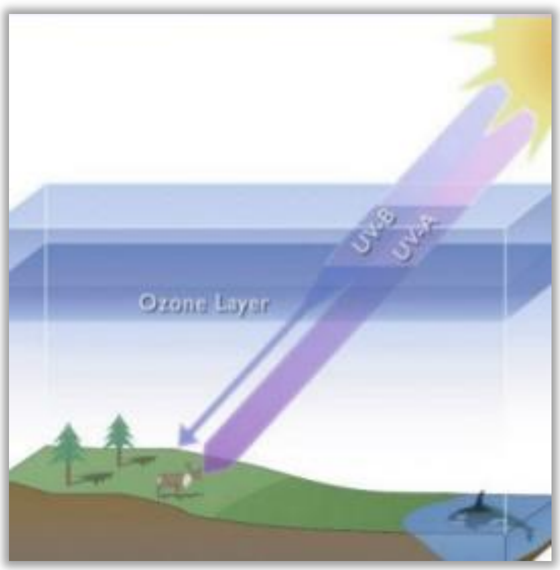
As the Earth continued to cool, the water vapor found in the atmosphere condensed to form the oceans and fresh water bodies on the continents. Early aquatic organisms called *blue-green algae* began using energy from the sun to split molecules of H_2O (water) and CO_2 and recombine them into organic compounds and molecular oxygen (O_2). This solar energy conversion process is known as ***photosynthesis***.



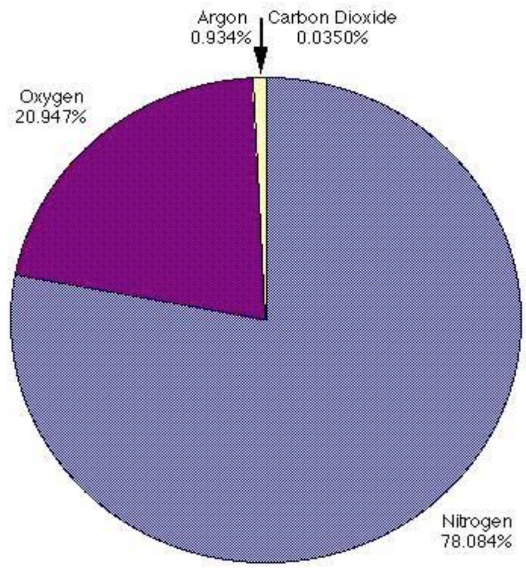


Without ozone, life could not exist on land because of harmful ***ultraviolet radiation***. High in the atmosphere, some oxygen (O_2) molecules absorbed energy from the Sun's ultraviolet (UV) rays and split to form single oxygen atoms. These atoms combine with remaining oxygen to form *"ozone"* (O_3) molecules, which are very effective at absorbing UV rays. The emergence of living organisms was extremely important in the creation of atmospheric oxygen and **ozone**.

The thin layer of ozone that surrounds Earth acts as a shield, protecting the planet from irradiation by UV light. UV rays penetrate the atmosphere at three slightly different wavelengths called UV-A, UV-B and UV-C. The ozone layer completely stops the penetration of UV-C and most of the UV-B rays. Therefore, the ozone layer protects life on Earth from the harmful effects of solar radiation on a daily basis.



Composition of the Present Atmosphere

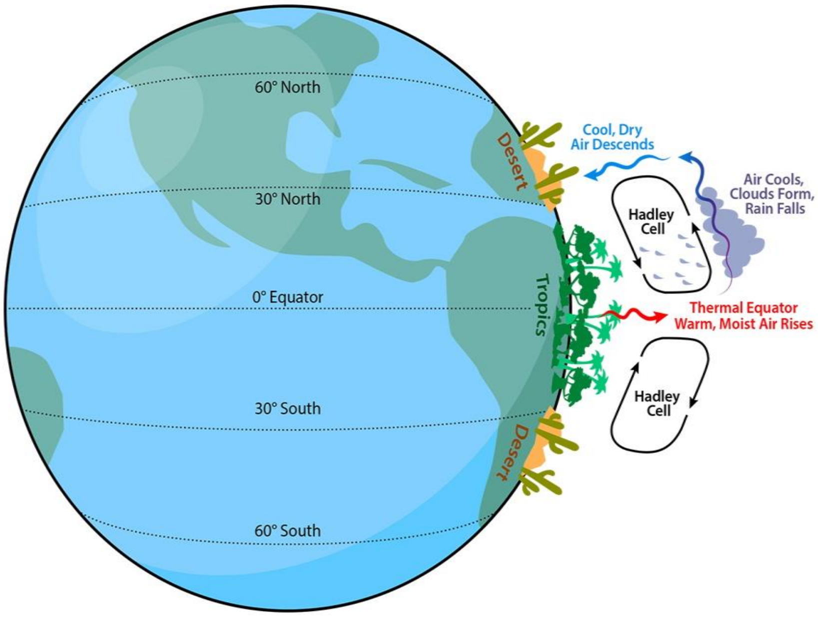


The atmosphere is composed of a mix of several different gases in differing amounts. The permanent gases whose percentages do not change from day to day are nitrogen, oxygen and argon. Nitrogen accounts for 78% of the atmosphere, oxygen 21% and argon 0.9%. Gases like carbon dioxide, nitrous oxides, methane, and ozone are trace gases that account for about a tenth of one percent of the atmosphere. Water vapor is unique- its concentration varies from 0-4% of the atmosphere depending on where you are and what time of the day it is. In the cold, dry artic regions water vapor usually accounts for less than 1% of the atmosphere, while in humid, tropical regions water vapor can account for almost 4% of the atmosphere. Water vapor content is very important in predicting weather.

Greenhouse gas percentages vary daily, seasonally, and annually and have physical and chemical properties that make them act together with solar radiation and infrared light (heat) given off from the earth to affect the energy balance of the planet. This is why scientists are watching the observed increase in greenhouse gases like carbon dioxide and methane carefully, because even though they are small in amount, they can strongly affect the global energy balance and temperature over time.

Atmospheric Circulation

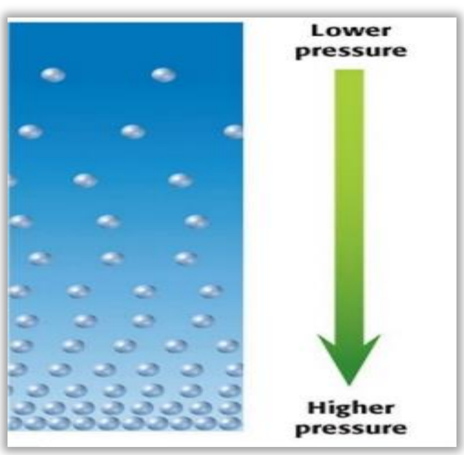
Atmospheric circulation is a major player in the climate of the Earth. The energy and circulation of the atmosphere can be witnessed by regular wind patterns such as the trade winds. Locally, we experience this mass movement of air molecules as a gentle breeze or the rare extreme of a tornado. The wind motion also transfers water evaporated from the oceans to the continents, providing precipitation critical to sustain terrestrial ecosystems.



The pattern of rising moist air near the equator and the sinking of dry air in the subtropics is referred to as ***Hadley Circulation***, a huge part of the general circulation of the atmosphere. It helps to transport heat from the equatorial regions to higher latitudes. Because of the Hadley circulation the tropics are warm and wet, while the subtropics are warm and dry. As a result of the atmospheric circulation patterns in the higher latitudes, the mid-latitudes experience high seasonal contrasts in temperature and rainfall patterns, while the Polar Regions are usually cold and dry. Rainfall in the mid-latitudes is controlled in part by the "polar front" or the "storm track." This expression refers to the day-to-day variations in the location and strength of the polar front.

The atmosphere is concentrated at the earth's surface and rapidly thins as you move upward, blending with space at roughly 100 miles above sea level. It is actually very thin compared to the size of the earth, equivalent in thickness to a piece of paper laid over a beach ball. However, it is responsible for keeping the earth habitable and for producing weather.

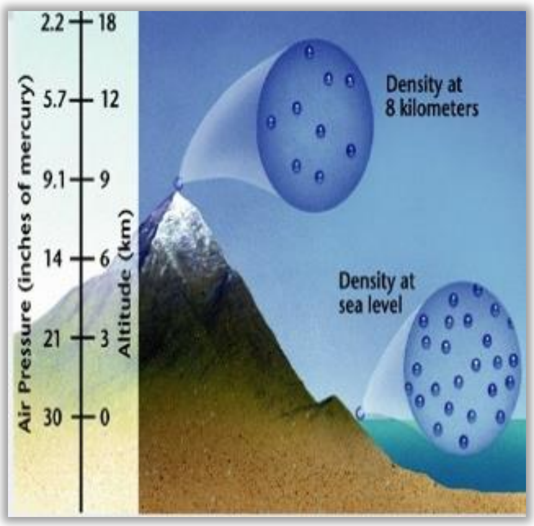
Atmospheric Temperature and Pressure



As Altitude Increases, Air Pressure Decreases

The atmosphere is held around the Earth by gravity. Gravity pulls gas molecules in the atmosphere toward the Earth's surface, causing air pressure. **Air pressure** is the measure of the force with which air molecules push on a surface. Air pressure is strongest at the Earth's surface because more air is above you. As you move farther away from the Earth's surface, fewer gas molecules are above you. As altitude (distance from sea level) increases, air pressure decreases.

Think of air pressure as a stack of books. The books at the bottom have all the weight and pressure of the books on top. Air pressure works in a similar way. People wonder why we are not crushed by air pressure. The reason is that the air pressure is equal in all directions, so air pushes equally on all sides and the forces are balanced.



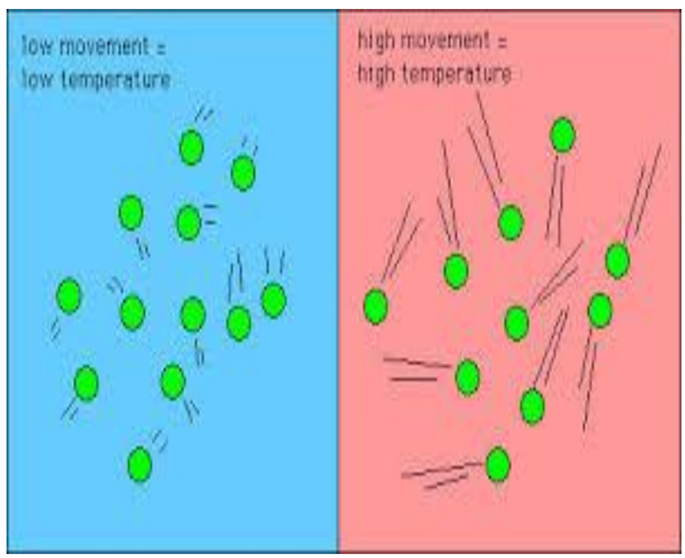
As the air pressure decreases, the density of the atmosphere also decreases. The air particles are not packed together as tightly as the altitude increases, since there is less gravity acting on the gas particles. The air at sea level and at 6km has the same 21% oxygen, but there are just fewer molecules taken in with each breath.

The traditional instrument for measuring air pressure was a ***barometer***, which used a glass tube filled with mercury to register the increasing and decreasing level in air pressure. However, we now know that mercury is a very dangerous substance and is not available for use in this capacity any longer. Modern measurements are done with a high tech ***pressure sensor***. These instruments use silicon chips and are airtight sealed, stainless steel containers with the pressure sensitive sensor inside.

Atmospheric Composition Affects Air Temperature

Air temperature also changes as altitude increases. The temperature differences result mainly from the way solar energy is absorbed as it moves through the atmosphere. Some parts of the atmosphere are warmer because they contain a high percentage of gases that absorb solar energy. Other parts of the atmosphere contain less of these gases and are cooler.

The uppermost atmospheric layer is called the ***thermosphere***. Here, temperature again increases with altitude because concentrations of- nitrogen and oxygen are high. Nitrogen and oxygen absorb solar radiation and release thermal energy, which causes temperatures in the thermosphere to be 1000 °C or higher.



When most people think of an area that has high temperatures, they think of a place that is very hot. Although the thermosphere has very high temperatures, it does not feel hot. ***Temperature*** is different from heat. Temperature is a measure of the average energy of particles in motion. The high temperature of the thermosphere means that particles in that layer are moving very fast. ***Heat***, however, is the transfer of thermal energy between objects of different temperatures. Particles must touch one another to transfer thermal energy. The space between particles in the thermosphere is so great that particles do not transfer much energy. In other words, the ***density*** of the thermosphere is so low that particles do not often collide and transfer energy.