

When a rocket takes off from the Earth's surface, it must push against the pressure of the atmosphere to escape into space. But what exactly is the atmosphere and why do we have to have so much force to break free of it? Earth's atmosphere is the envelope of gases that surrounds the planet. The atmosphere is so thin that if the Earth was the size of an apple, and you were to exhale onto the apple, the condensation that forms would be about the thickness of the atmosphere.

### *Composition*

The atmosphere is made up of a mixture of different atoms and molecules. Earth's atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor, and small amounts of other gases.

**Nitrogen:** Nitrogen is the most abundant gas in the atmosphere. It makes up a little more than  $\frac{3}{4}$  of the air we breathe.

**Oxygen:** Even though oxygen is the second most abundant gas in the atmosphere, it makes up less than  $\frac{1}{4}$  of the volume. Why is oxygen such an important gas?

**Carbon Dioxide:** Each molecule of carbon dioxide has one atom of carbon and two atoms of oxygen. Why is carbon dioxide essential to life? What produces carbon dioxide?

**Other Gases:** Oxygen and nitrogen together make up 99% of Earth's atmosphere. Carbon dioxide makes up most of the remaining 1%. The remaining gases are called trace gases because only small amounts of them are present.

### *Importance of the Atmosphere*

The Earth's atmosphere makes conditions on Earth suitable for living things. The atmosphere contains oxygen and other gases that you and other living things need to survive. In turn, living things affect the atmosphere.

By trapping the energy from the Sun, Earth's atmosphere keeps most of Earth's surface warm enough for liquid water to exist. In addition, Earth's atmosphere protects living things from dangerous radiation from the Sun and prevents Earth's surface from being hit by most meteorites.

### *Layers of the Atmosphere*

Scientists divide Earth's atmosphere into four main layers classified according to changes in temperature. These layers are the troposphere, the stratosphere, the mesosphere, and the thermosphere.

**Troposphere:** We live in the inner, or lowest layer of the atmosphere called the troposphere. Conditions in the troposphere are more variable than in the other layers. The troposphere is the layer of the atmosphere where weather occurs.

As altitude increases in the troposphere, the temperature decreases. At the top of the troposphere, the temperature stops decreasing and stays at about  $-60^{\circ}\text{C}$ .

**Stratosphere:** The stratosphere extends from the top of the troposphere to about 50 km above Earth's surface. The stratosphere is the second layer of the atmosphere and contains the ozone layer.

The lower stratosphere is cold ( $\sim 60^{\circ}\text{C}$ ). But, the upper stratosphere is warmer than the lower stratosphere! Why is that? The middle portion of the stratosphere contains a layer of air where there is much more ozone than the rest of the atmosphere. When the ozone absorbs energy from the sun, the energy is converted to heat, which warms the air. The ozone layer is important because it protects living things from ultraviolet radiation.

**Mesosphere:** Above the stratosphere, a drop in temperature marks the beginning of the next layer, the mesosphere. In the outer mesosphere, temperatures approach  $-90^{\circ}\text{C}$ . The mesosphere is the layer of the atmosphere that protects the Earth's atmosphere from being hit by meteorites.

**Thermosphere:** The outermost layer of the Earth's atmosphere is the thermosphere. The thermosphere has no definite outer limit, but blends gradually with space. The air in the thermosphere is very thin: only about 0.001 percent as dense as the air at sea level. Even though the air is thin, it is very hot, up to  $1,000^{\circ}\text{C}$ . This is because sunlight strikes the thermosphere first and the oxygen and nitrogen molecules sitting there convert this energy to heat.

Even though the temperature is quite high, if you were to hop out of a space shuttle here, it would feel extremely cold. Why? Temperature is the average amount of motion of each molecule of a substance. The gas molecules in the thermosphere move very rapidly, so the temperature is high. However, the molecules are spread very apart in the thin air, so there are not very many of them to collide with a thermometer.

### *Air Pressure*

Did you know that the weight of the atmosphere itself is constantly pressing on your body? It may seem that air has no mass, but in fact, we know air is

composed of atoms and molecules, each of which have mass. So air must have mass. Because air has mass, it also has other properties, including density and pressure.

Density: The amount of mass in a given volume of air is its density. You can calculate the density of a substance by dividing its mass by its volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

What kind of relationship is this? [Direct variation to Mass and indirect variation to volume]

Pressure: the force pushing on an area or surface is known as pressure. The weight of the atmosphere exerts a force on surfaces. Air pressure is the result of the weight of a column of air pushing down on an area. The column of air extends upward through the entire atmosphere.

The atmosphere is really heavy! The weight of a column of air above you is about the weight of a yellow school bus! So, why doesn't air pressure crush you? Molecules are pushing in all directions. So the air pushing down is counter balanced by the air pushing up.

Air pressure changes from day to day. A denser substance has more mass per unit than a less dense one. So, denser air exerts more pressure than less dense air.

#### *Altitude and the Properties of Air*

At the top of a mountain, the air pressure is less than the air pressure at sea level. Altitude, or elevation, is the distance above sea level (the average level of the surface of the oceans). Air pressure decreases as altitude increases. As air pressure decreases, so does density.

Imagine a stack of books. Which book has the most weight on it? Which book has more weight, the second book from the top or the book at the bottom? Air at sea level is like the bottom book. Sea level air has the weight of the whole atmosphere pressing on it. So air pressure is greater at sea level. Air near the top of the atmosphere is like the second book from the top. There, the air has less weight pressing on it and, so, lower air pressure.

As you go up through the atmosphere, the density of the air decreases. This means the gas molecules that make up the atmosphere are farther apart at high altitudes than they are at sea level. So then, why is it hard to breathe at the top of a mountain?

Images used in this lesson:



Atmospheric Layers

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Temperature variation in the atmosphere

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Earth's Atmosphere from Space

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