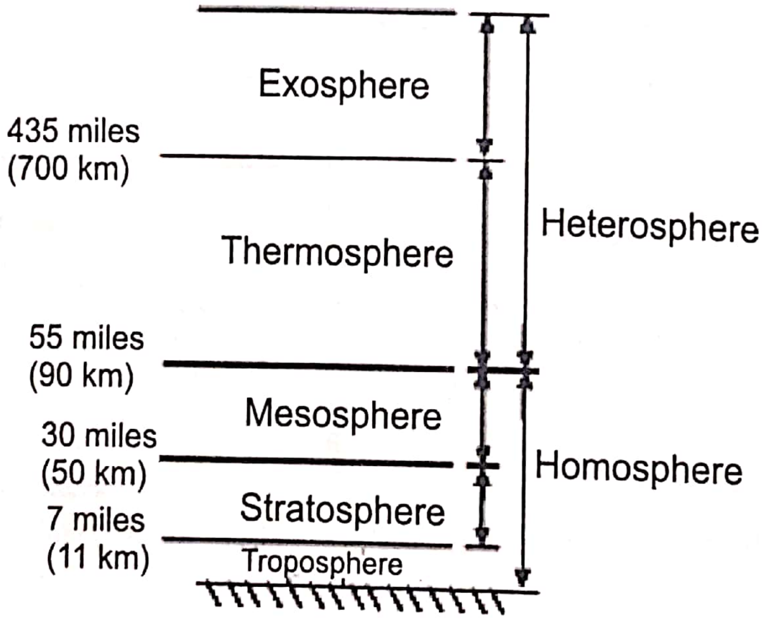
ATMOSPHERIC COMPOSITION & STRUCTURE

Atmosphere can be defined as:

"Atmosphere is an envelope of gases held around the earth because of its gravitational pull."

An atmosphere is a layer of gases that may surround a material body of sufficient mass. The gases are attracted by the gravity of the body, and are retained for a longer duration if gravity is high and the atmosphere's temperature is low.

Two gases, nitrogen and oxygen, make up most of the atmosphere by volume. They are indeed important for maintaining life and driving a number of processes near the surface of the Earth.



ATMOSPHERIC COMPOSITION

Two broad regions can be identified using air composition as a means to subdivide the atmosphere. The **heterosphere** is the outermost sphere where gases are distributed in distinct layers by gravity according to their atomic weight. Extending from an altitude of 80 km (50 mi), the lightest elements (hydrogen and helium) are found at the outer margins of the atmosphere. The heavier elements (nitrogen and oxygen) are found at the base of the layer.

HOW DID EARTH'S ATMOSHPHERE DEVELOP

It is believed that the atmosphere (air) that we now breathe was formed only after the development of the first living things, blue-green algae (now generally classified as blue-green bacteria), that happened about two billion years ago. These simple organisms used carbon dioxide during photosynthesis and gave off oxygen as a biproduct of the chemical process.

The **homosphere** lies between the Earth's surface and the heterosphere. Gases are nearly uniformly mixed through this layer even though density decreases with height above the surface.

Following gases are present in homosphere:

1. Permanent Gases

The permanent gases that make up the atmosphere by volume are nitrogen (78%), oxygen (21%) and argon (.93%). Physical geographers often refer to these gases as the "permanent gases" because their concentration has remained virtually the same for much of recent earth history.

Nitrogen is a relatively inert gas produced primarily by volcanic activity. It is an important component of protein in meat, milk, eggs and the tissues of plants, especially grains and members of the pea family. It cannot be ingested directly by organisms but made available to plants, and then to animals, by compounds in the soil. Most atmospheric nitrogen enters the soil by nitrogen-fixing microorganisms.

Oxygen is important for plant and animal respiratory processes. It is also important to chemical reactions (oxidation) that break down rock materials (chemical weathering). Without oxygen, things cannot burn either. Free oxygen in the atmosphere is a product of plant photosynthesis. Plants take up carbon dioxide and in the process of photosynthesis, release oxygen.

2. Variable Gases

The so-called "variable" gases are those present in small and variable amounts. These include carbon dioxide, methane, ozone, water vapour, and particulates among others. Even though they represent a tiny portion of the atmosphere as a whole, they exert a great control over our environment.

2.1. Carbon Dioxide

Carbon dioxide (CO_2) makes up only .036% of the atmosphere by volume. Carbon dioxide is essential to photosynthetic processes in plants. Huge quantities of carbon are stored in plant tissue, deposits of coal, peat, oil, and gas. Carbon dioxide is taken in by plants and during photosynthesis is combined with water and energy to form oxygen and carbohydrates.

> **INTERESTING FACT**
> A person breathes about 16 kg of air every day. As a comparison, we consume 0.7 kg of food and 1.4 kg to 2.3 kg of water per day. Needless to say, the quality of the air around us does have a significant impact on our health.

2.2. Water Vapour

Water vapour is an extremely important gas found in the atmosphere. It can vary from 4% in the steamy tropics to nearly non-existent in the cold dry regions of the Antarctic. Water vapour is a good absorber of Earth's outgoing radiation and thus is considered a greenhouse gas. When water vapour is converted to a liquid during condensation, clouds are formed. Clouds are good absorbers of radiation given off by the Earth's surface. The absorption of this energy raises the temperature of the air. But clouds are generally light-coloured and hence reflect incoming solar radiation off their tops. The reflected light is sent back to space, never reaching the ground to warm the Earth. Thus clouds can have either a warming or a cooling effect on air temperature.

2.3. Particulates and Aerosols

Atmospheric particulates and aerosols are very small particles of solid or liquid, suspended in the air. Particulates and aerosols play several important roles in atmospheric processes. Particulate matter includes dust, dirt, soot, smoke, and tiny particles of pollutants. Major natural sources of particulates are volcanoes, fires, wind-blown soil and sand, sea salt, and pollen. Human sources such as factories, power plants, trash incinerators, motor vehicles and construction activity also contribute particulates to the atmosphere.

2.4. Methane

Methane (CH_4) is a greenhouse gas contributing to about 18% of global warming and has been on the rise over the last several decades. Though methane makes up far less of the atmosphere (.0002%) than carbon dioxide, it is 20 times more potent than CO_2 as a greenhouse gas. Methane is a product of the decomposition of organic matter, with major natural sources being that which occurs from wetlands, termites, the oceans and hydrates.

2.5. Ozone

Ozone (O_3) is both beneficial and harmful to life on Earth. Much of the ozone in the atmosphere is found in the stratosphere. Here, ozone absorbs UV light from the sun preventing it from reaching the surface. Without this blanket, humans would be exposed to serious sun burns and potential risk of skin cancer. Ozone is also found in the lowest layer of the atmosphere, the troposphere. Here ozone can act as an eye and respiratory irritant. Ozone also causes cellular damage inside the leaves of plants causing brown splotches, impairing carbon dioxide uptake and disrupting the photosynthetic apparatus. Such damage can cause economic losses through reduced crop yields. It also damages the carbon "sink" role of vegetation leaving more carbon dioxide in the atmosphere to enhance the greenhouse effect and potential global warming.

ATMOSPHERIC STRUCTURE

TROPOSPHERE AND TROPOPAUSE

The troposphere is the layer closest to the Earth's surface. The graph of temperature-change indicates that air temperature decreases with an increase in altitude through this layer. Air temperature normally decreases with height above the surface because the primary source of heating for the air is the Earth. The rate of change in temperature with altitude is called the environmental lapse rate of temperature (ELR). The ELR varies from day-to-day at a place, and from place-to-place on any given day. The ***tropopause*** lies above the troposphere. Here, the temperature tends to stay the same with increasing height. The tropopause acts as a "lid" on the troposphere preventing air from rising upwards into the stratosphere.

> **BRIEF FACTS**
> Air pressure changes with altitude. When you move to a higher place, say a tall mountain, air pressure decreases because there are fewer air molecules as you move higher in the sky.

THE STRATOSPHERE

The stratosphere is the next layer of the atmosphere. Here, the air doesn't flow up and down, but flows parallel to the earth in very fast moving air streams. This is the layer where most jet planes fly. The stratosphere starts at approximately 16 kilometres and goes to approximately 50 kilometres high (about 30 miles). The **ozonosphere, also called the "ozone layer"**, is the concentrated layer of ozone found in the stratosphere. Ozone (O_3) absorbs ultraviolet light between 0.1-0.3μm. The ozone layer absorbs 97-99% of the Sun's ultraviolet light that can be harmful to life on earth. The top edge of the stratosphere is abundant with ozone. Ozone is the by-product of sun radiation and oxygen; by capturing the ultraviolet rays of the sun and deploying it, ozone takes out the harmful effects. This is very important to all living things on earth, since unfiltered radiation from the sun can destroy all animal tissue. After the stratosphere there is again a buffer layer, this time called the stratopause.

Under the right conditions, the air temperature may actually increase with an increase in altitude above the Earth. When this occurs, we are experiencing an inverted lapse rate of temperature, or simply an *inversion*. Through most of the stratosphere, the air temperature increases with an increase in elevation creating a temperature inversion. The inverted lapse rate of temperature is due to the presence of stratospheric ozone which is a good absorber of ultraviolet radiation emitted by the sun. As energy penetrates downward, less and less is available for lower layers and hence the temperature decreases toward the bottom of the stratosphere. The downward reduction of heat transfer due to solar energy absorption from above is offset by the heat given off by the Earth creating the isothermal layer at the bottom of the stratosphere. At the top of the stratosphere lies the stratopause. Like the tropopause, the stratopause is an isothermal layer that separates the stratosphere from the mesosphere.

The Mesosphere

Above this, from thirty miles up to fifty miles, is the mesosphere. This area reaches the coldest temperatures of all the atmosphere, going to -130 degrees and lower. Here, meteors coming too close to earth burn up. 99.9 percent of the gases that comprise the atmosphere lie below this level. The air of the mesosphere is thus extremely thin and air pressure very small. With very few molecules like ozone capable of absorbing solar radiation, especially near the top of the layer, the air temperature decreases with height. The mesopause separates the mesosphere from the thermosphere above.

The Thermosphere

The last layer of the atmosphere, called the thermosphere, contains less than 0.01% of all air within the atmospheric envelope. Temperatures here reaches upward to 2000 degrees, but the gas molecules making up the air are so far apart the temperature is not felt. Air temperature increases with increasing altitude in the **thermosphere.** Here, energetic oxygen molecules absorb incoming solar radiation raising the layer's temperature. Because solar activity determines the temperature of the layer, temperature at the top of the layer is warmer than that near the bottom of the thermosphere. Even though the temperatures are quite high in the thermosphere, the heat content of the layer is very low due to the low density of air at this level.

The outer edge of the thermosphere is an area called **the ionosphere** and is not a separate layer. The ionosphere is not really a layer of the atmosphere, but an electrified field of ions and free electrons. The ionosphere absorbs cosmic rays, gamma rays, X-rays, and shorter wavelengths of ultraviolet radiation. Gas atoms drift into space from here. It is called ionosphere because in this part of the atmosphere, the sun's radiation is ionized, or pulled apart, as it travels Earth's magnetic fields to the north and south poles. This pulling apart is seen from earth as auroras.

The colourful displays of auroras are called the Northern Lights or aurora borealis in the Northern Hemisphere, the Southern Lights or Aurora Australis in the Southern Hemisphere. The part of thermosphere extending from ionosphere up to the space or interplanetary gases is called **exosphere.**