The Earth has 4 spheres:

- Lithosphere: (land) This includes all the rocks that make up the Earth, from the partially melted rock under the crust to grains of sand on a beach. The geosphere also provides natural resources and a place to grow food.
- Biosphere: (living things) This is the narrow zone where land, water, and air come together.
- Hydrosphere: (water) This is the area of the Earth's surface that is covered by water.
- Atmosphere: (air) This is the gaseous layers that surround the Earth.

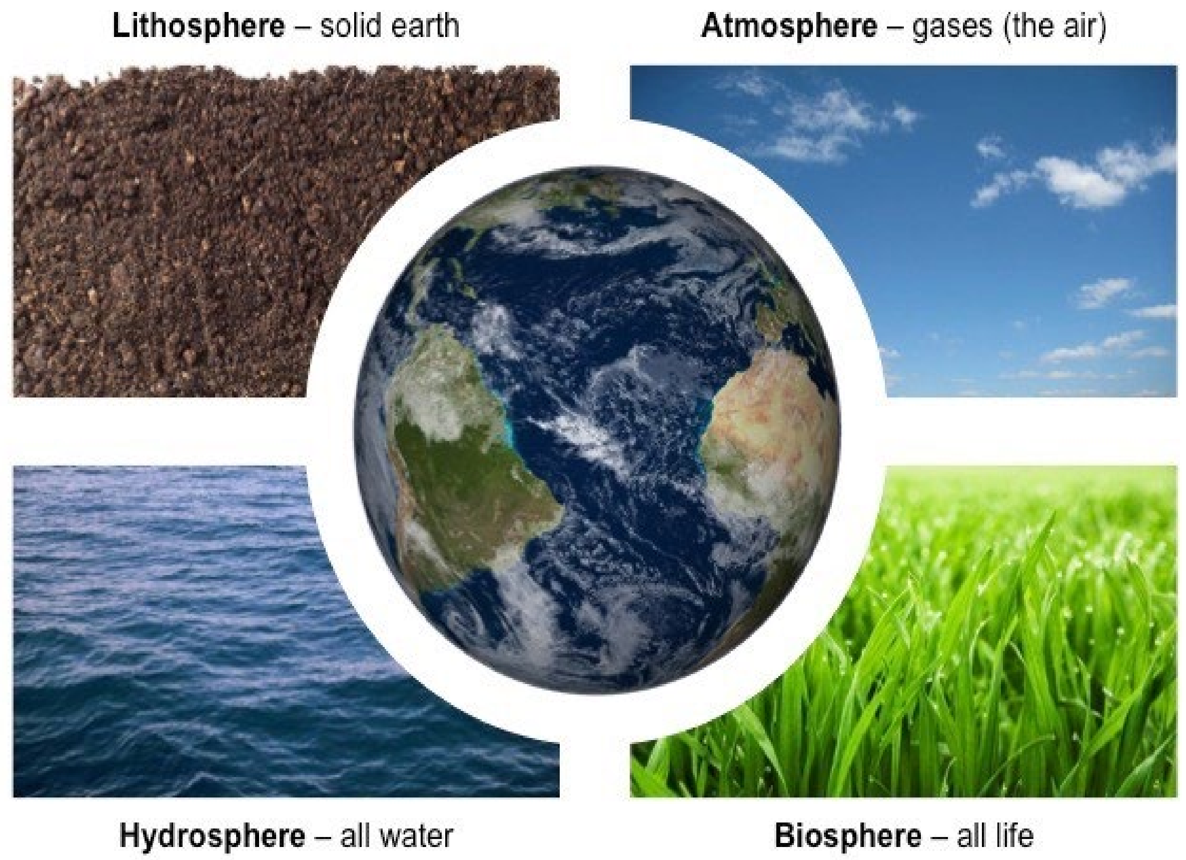

Image 1**. 4 Spheres of Earth** (https://ib.bioninja.com.au/options/option-c-ecology-and-conser/c3-impacts-of-humans-on/earth-spheres.html)

Atmosphere-

The envelope of gas and or dust particles that surrounds the various celestial bodies of the universe, due to the force of gravity is called atmosphere.

Earth's atmosphere is composed of about 78% nitrogen, 21% oxygen, and 1% other gases.

Nitrogen (N2): It is the most plentiful gas in the air. It is one of the primary nutrients critical for the survival of all living organisms.

(O2): Humans and animals take oxygen from the air as they breathe. Green plants produce oxygen during photosynthesis. In this way oxygen content in the air remains constant.

Carbon dioxide (CO2): It is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels.

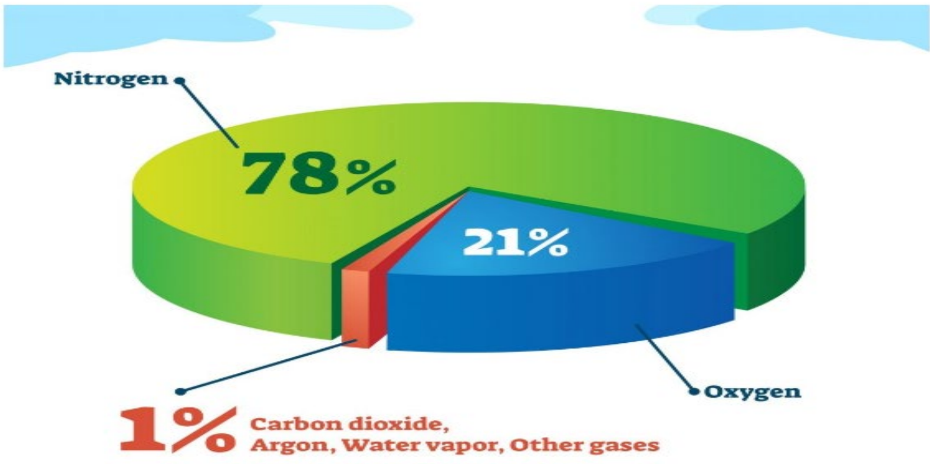

Image 2. Drishti IAS

Layers of atmosphere based on vertical temperature profile

Air temperature throughout atmosphere shows complicated vertical profile and may be divided into five main distinguished layers, namely **troposphere, stratosphere, mesosphere, thermosphere and exosphere**. They are layered one atop the other and each one is very much needed to support and protect the life on the earth. The atmospheric also contains transition layers between two successive main layers. The nomenclature of these transitional layers zones contains the term – pause at its end. These are tropopause (from the end of troposphere and till the beginning of stratosphere), stratopause (boundary separating stratosphere from mesosphere), mesopause (transition region between mesosphere and thermosphere) and thermopause (between thermosphere and exosphere)

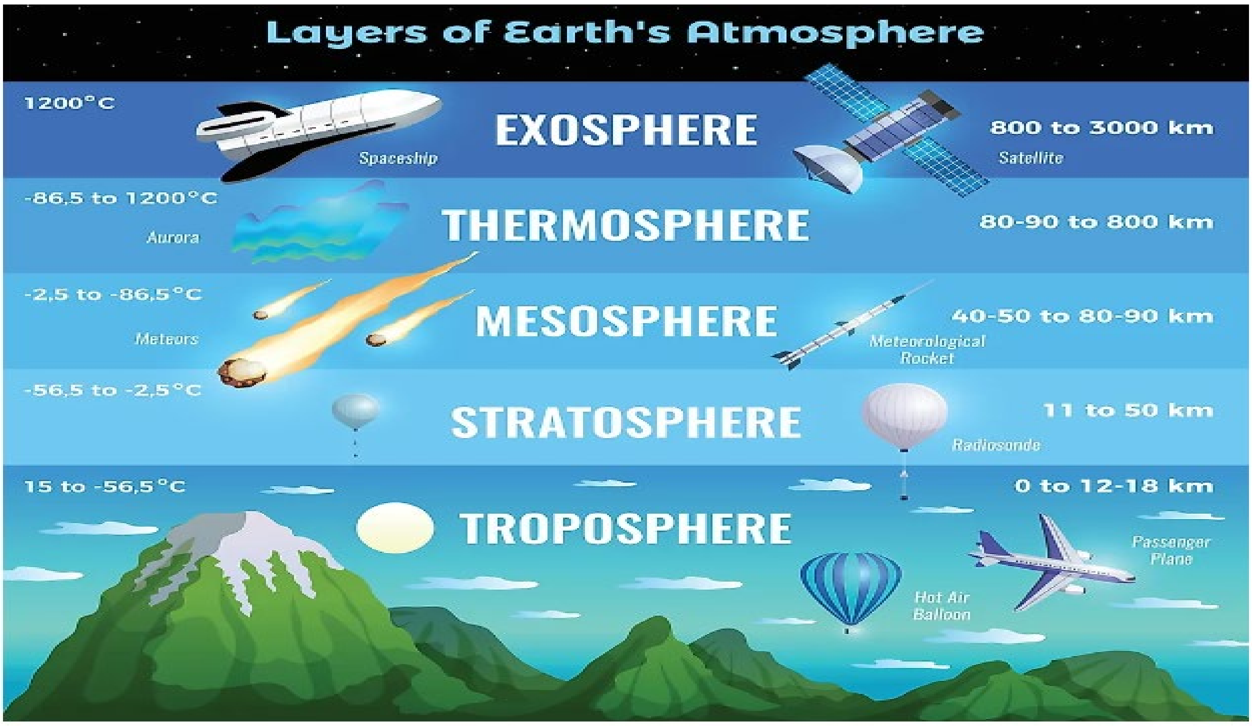

Image 3. Layers of Atmosphere (Drishti IAS)

Troposphere:

Earth's troposphere extends from Earth's surface to, on average, about 12 kilometers in height, with its height lower at **Earth's poles** and higher at the equator. (18 km at equator, 8 km at poles). The depth of the troposphere is influenced by the latitude, season and time of the day. The reasons behind the non-uniformity in thickness of the troposphere are:

1. Equator gets high insolation
2. Higher gravitational pull on atmospheric gases at poles
3. Equator has highest centrifugal force due to earth's rotation

Holding all the air that plants need for **photosynthesis** and animals need to breathe, and also **contains about 99% of all water vapor and aerosols** (minute solid or liquid particles suspended in the atmosphere).

The temperature in the troposphere also decreases with height. On top of this layer is what is referred to as Tropopause-Isothermal layer, it can be observed that just above a certain height of the troposphere, the **lapse rate becomes zero** which means the air temperature (about - 60°C) remains constant with altitude in that region i.e. an isothermal (equal temperature) layer. The bottom of this layer represents top of the troposphere and its upper limit as the starting point of the stratosphere

It is the **densest atmospheric layer,** compressed by the weight of the rest of the atmosphere above it.

Most of **Earth's weather happens here, and almost all clouds that are generated by weather are found here.**

Most **aviation takes place here,** including in the transition region between the troposphere and the stratosphere.

Lapse rate – decrease temperature with altitude, (- 6.5°C) per kilometre (1°C per 155 m)

Stratosphere:

Located between approximately 12 and 50 kilometers above Earth's surface, the stratosphere is perhaps **best known as home to Earth's ozone layer.**

In this region, **the temperature increases with height.** Heat is produced in the process of the formation of Ozone, and this **heat is responsible for temperature increase.**

It is **nearly cloud- and weather-free, but polar stratospheric clouds** (occur mainly at high latitudes during the winter) **are sometimes present** in its lowest, coldest altitudes.

It's also the **highest part of the atmosphere that jet planes can reach.**

Mesosphere:

Located between about 50 and 80 kilometers above Earth's surface, the mesosphere **gets progressively colder with altitude.**

The top of this layer is the **coldest place found within the Earth system,** with an average temperature of about minus 85 °C (-120 °F).

The very scarce **water vapor present at the top of the mesosphere forms noctilucent clouds**, the **highest clouds in Earth's atmosphere.**

Most **meteors burn up in this atmospheric layer.** Sounding rockets and rocket-powered aircraft can reach the mesosphere.

The transition boundary which **separates the mesosphere from the stratosphere is called the stratopause.**

Thermosphere:

The thermosphere is located above the mesosphere. The temperature in the thermosphere generally increases with altitude reaching 600 to 3000 F (600-2000 K) depending on solar activity. This increase in temperature is due to the absorption of intense solar radiation by the limited amount of remaining molecular oxygen. At this extreme altitude gas molecules are widely separated. Above 60 miles (100 km) from Earth's surface the chemical composition of air becomes strongly dependent on altitude and the atmosphere becomes enriched with lighter gases (atomic oxygen, helium and hydrogen). Also, at 60 miles (100 km) altitude, Earth's atmosphere becomes too thin to support aircraft and vehicles need to travel at orbital velocities to stay aloft. This demarcation between aeronautics and astronautics is known as the **Karman Line**. Above about 100 miles (160 km) altitude the major atmospheric component becomes atomic oxygen. At very high altitudes, the residual gases begin to stratify according to molecular mass, because of gravitational separation.

It is located between about 80 and 700 kilometers above Earth's surface, whose **lowest part contains the ionosphere.**

In this layer, temperatures increase with altitude due to the very low density of molecules found here. **It is both cloud- and water-vapor-free.**

The **aurora borealis** (Northern lights) and **aurora australis** (Southern lights) are sometimes seen here.

The **International Space Station (ISS)** orbits in the thermosphere.

Ionosphere:

It is not a distinct layer as the others mentioned above. Instead, the ionosphere overlaps the mesosphere, thermosphere, and exosphere. It's a very active part of the atmosphere, and it grows and shrinks depending on the energy it absorbs from the sun.

It is an electrically conducting region capable of reflecting radio signals back to Earth. The electrically charged atoms and molecules that are formed in this way are called ions, giving the ionosphere its name and endowing this region with some special properties.

The ionosphere is defined by atmospheric effects on radiowave propagation as a result of the presence and variation in concentration of free electrons in the atmosphere. **DEF**

D-region is about 35 to 55 miles (60 - 90 km) in altitude but disappears at night.

E-region is about 55 to 90 miles (90 - 140 km) in altitude. It is also known as **Heavyside-Kennely layer**
F-region is above 90 miles (140 km) in atitude. During the day it has two regions known as the F1-region from about 90 to 115 miles (140 to 180 km) altitude and the F2-region in which the concentration of electrons peaks in the altitude range of 150 to 300 miles (around 250 to 500 km)

$F_1 + F_2$ = Appleton Layer

Some important phenomena of Ionosphere

Ionospheric Scintillation

- Scintillation influences the phase and power of the propagating radio signal. Ionospheric scintillation is the fast alteration of radio waves produced by small scale structures in the ionosphere. Severe scintillation can stops a GPS receiver from getting the accurate signal and produces huge errors in position calculation. Low and high latitudes exhibit more prominent scintillation over mid-latitudes (e.g. the United States).

Aurora

- The aurora are illusive natural electro-magnetic phenomenon with luminous (light) effect, which usually occurs near the **northern (Aurora Borealis) and southern (Aurora Australis)** poles in the night sky, best developed at a height of about 90 km.

Image 4. Aurora (Shutterstock)

Such effects are probably the result of magnetic storms and of electrical discharges from the sun during periods of sun-spot activity, causing ionization of gases, though this is still a matter of research. The origin of aurora can be traced to **solar flares** which are huge eruptions on the surface of the sun that occur periodically (every **11 years**). Most of the solar radiation returns back to the sun, but some ionized particles are ejected into space at very high speeds. These solar flares travel at the speed of roughly 1.5×10^6 m s-1 and enter the earth's atmosphere 30 hours after the occurrence of solar flares. Sine these particles are electrically charged, they are deflected towards the north and south poles by the magnetic fields of the earth. When these high-speed charged particles collide with the air molecules, they cause electrons to be freed. When the electrons recombine with air molecules, energy in the form of light is emitted.

Exosphere:

It is located between about 700 and 10,000 kilometers above Earth's surface, the exosphere is the **highest layer of Earth's atmosphere** and, at its top, merges with the **solar wind.**

Molecules found here are of extremely low density, so **this layer doesn't behave like a gas, and particles here escape into space.**

While **there's no weather in the exosphere**, the aurora borealis and aurora australis are sometimes seen in its lowest part.

Most Earth satellites orbit in this layer.

Significance of Atmosphere

Protection from Harmful Radiations: The atmosphere protects life on Earth by shielding it from incoming ultraviolet (UV) radiation, keeping the planet warm through insulation, and preventing extremes between day and night temperatures.

Weather and climate: The atmosphere play a crucial role in determining weather and climate patterns, including temperature, precipitation, and wind. These patterns have a significant impact on ecosystems, agriculture, and human activities.

Regulates the Earth's Temperature: The atmosphere helps regulate the Earth's temperature by trapping heat from the sun and preventing it from escaping into space. This process, known as the greenhouse effect, helps keep the planet warm enough to support life.

A Major Role in the Water Cycle: The atmosphere helps regulate the Earth's water cycle by transporting water vapor from the oceans to the land, where it falls as precipitation.

Residence Time (or lifetime) is defined as the amount of the chemical in the atmosphere divided by the rate at which the chemical is removed from the atmosphere.

- **Homosphere:** Up to 90 km, Homogeneous Gas Concentration (78 % N_2, 21 % O_2)
- **Heterosphere:** beyond 90 km

Major constituents of dry air, by volume[7]

Gas		Volume(A)	
Name	**Formula**	**in ppmv(B)**	**in %**
Nitrogen	N_2	780,840	78.084
Oxygen	O_2	209,460	20.946
Argon	Ar	9,340	0.9340
Carbon dioxide	CO_2	400	0.04[8]
Neon	Ne	18.18	0.001818
Helium	He	5.24	0.000524
Methane	CH_4	1.79	0.000179
Not included in above dry atmosphere:			
Water vapor(C)	H_2O	10–50,000(D)	0.001%–5%(D)

notes:

(A) volume fraction is equal to mole fraction for ideal gas only, also see volume (thermodynamics)
(B) ppmv: parts per million by volume
(C) Water vapor is about 0.25% *by mass* over full atmosphere
(D) Water vapor strongly varies locally[5]

Average Composition of the Troposphere

Gas Name	Formula	Abundance (%)	Residence time (approx)
Nitrogen	N_2	78.08%	42,000,000 years
Oxygen	O_2	20.95%	5,000 years
*Water	H_2O	0 to 4%	10 days
Argon	Ar	0.93%	~Infinite
*Carbon Dioxide	CO_2	0.0360%	4 years
Neon	Ne	0.0018%	~Infinite
Helium	He	0.0005%	~Infinite
*Methane	CH_4	0.00017%	10 years
Hydrogen	H_2	0.00005%	3 years
*Nitrous Oxide	N_2O	0.00003%	170 years
*Ozone	O_3	0.000004%	20 days

*variable gases

Facts:

- About 99% of the total atmospheric mass is concentrated in the first 20 miles (32 km) above Earth's surface.
- Around 80% of the mass of the total atmosphere contain troposphere
- 90% mass up to 20km
- The ozone layer is at an altitude between 10-15 miles (15-25 km). Approximately 90 % of the ozone in the atmosphere resides in the stratosphere