Direct & Indirect Sources for Understanding the Earth's Interior

The Earth's surface is shaped by geological processes, driven by forces from above and below:

- Endogenous Processes: These are caused by forces from within the Earth (endogenous meaning "in"). They lead to major features like mountains, plateaus, and lakes. These processes include folding and faulting, primarily driven by internal forces.
- Exogenous Processes: These result from forces on or above the Earth's surface (exogenous meaning "out"). While they also influence the surface, endogenous processes have a more significant role in shaping it.
- Geophysical Phenomena: Catastrophic events like earthquakes and volcanic eruptions are primarily caused by forces deep below the Earth's surface. For instance, earthquakes result from tectonic plate movements, fueled by mantle convection currents. Volcanism, on the other hand, occurs through vents and fissures created by tectonic activity.

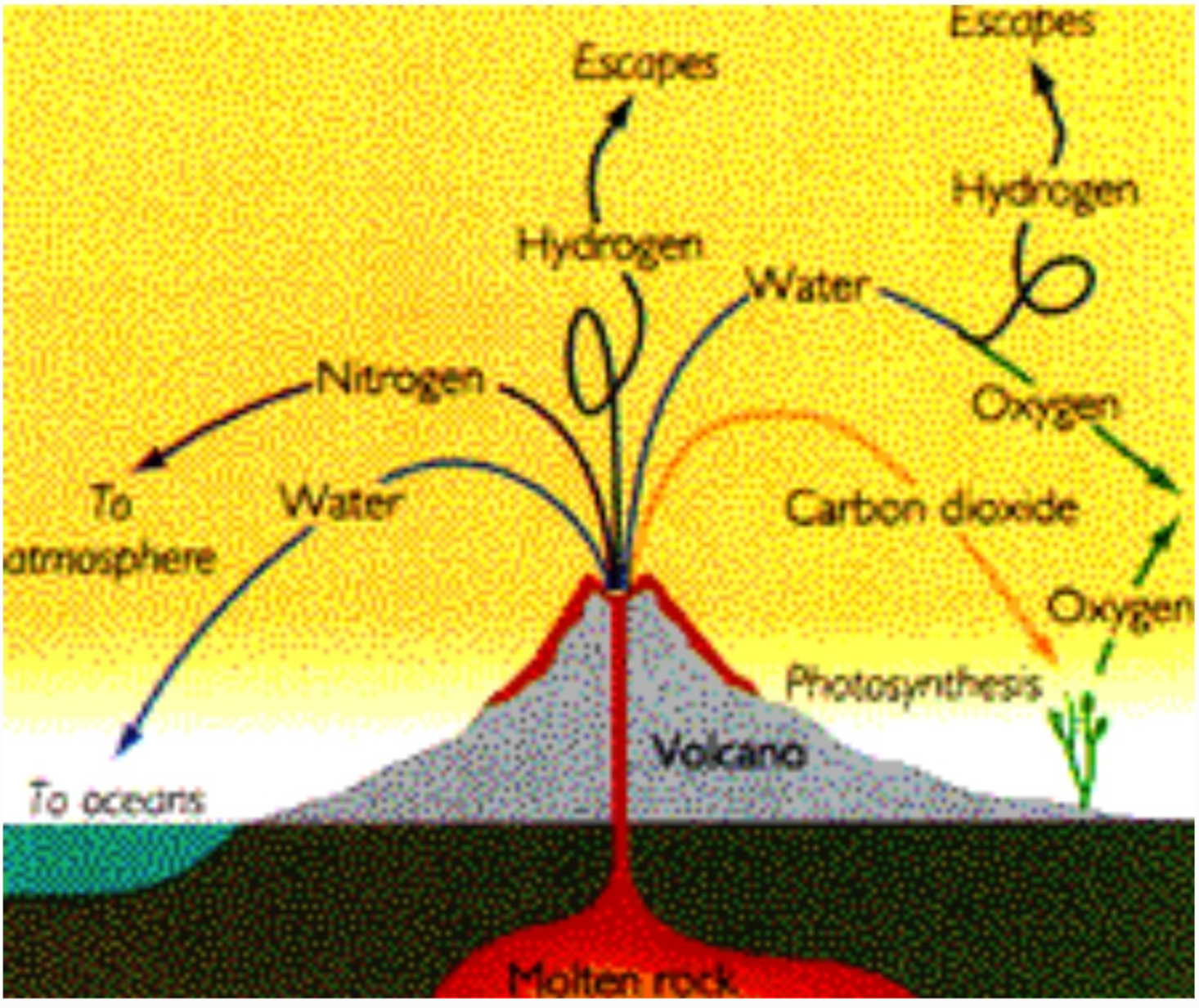
Indirect methods to learn about the Earth's interior include:

- Pressure and temperature rise with depth.
- Seismic waves.
- Meteorites.
- Gravitational effects and Earth's size for pressure estimates.
- Volcanic eruptions and hot springs indicate a hot interior.

Source	Description	What It Reveals About Earth's Interior
Increase in Pressure and Temperature with Depth	Pressure and temperature increase with depth, estimated through Earth's diameter.	Helps estimate pressure deep inside the Earth and reveals a very hot interior through volcanic eruptions, hot springs, and geysers.
Seismic Waves	Seismic waves change velocity, reflect, or refract as they travel through different layers of the Earth.	The most important source for understanding Earth's layered structure. Reveals changes in elasticity and density of materials at various depths.

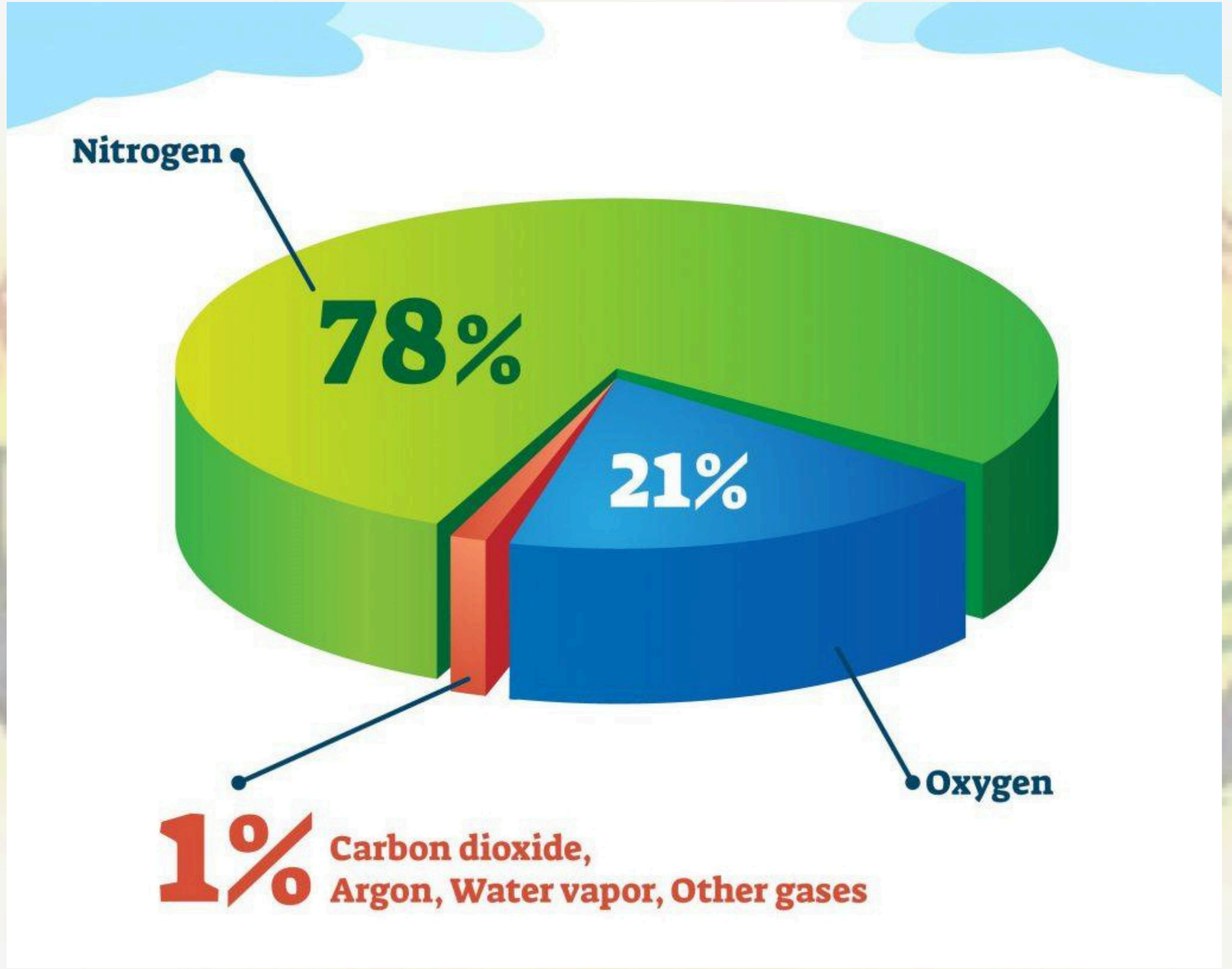
Meteorites	Meteorites and Earth share a common origin from the same nebular cloud, and their cores reveal heavy materials.	Suggests that Earth's inner core has a similar heavy material composition as meteorite cores.
Magnetic Field	Changes in Earth's magnetic field, caused by the geodynamo effect, give clues to core composition and activity.	Offers insights into the composition and behavior of the iron core through shifts in the magnetic field.

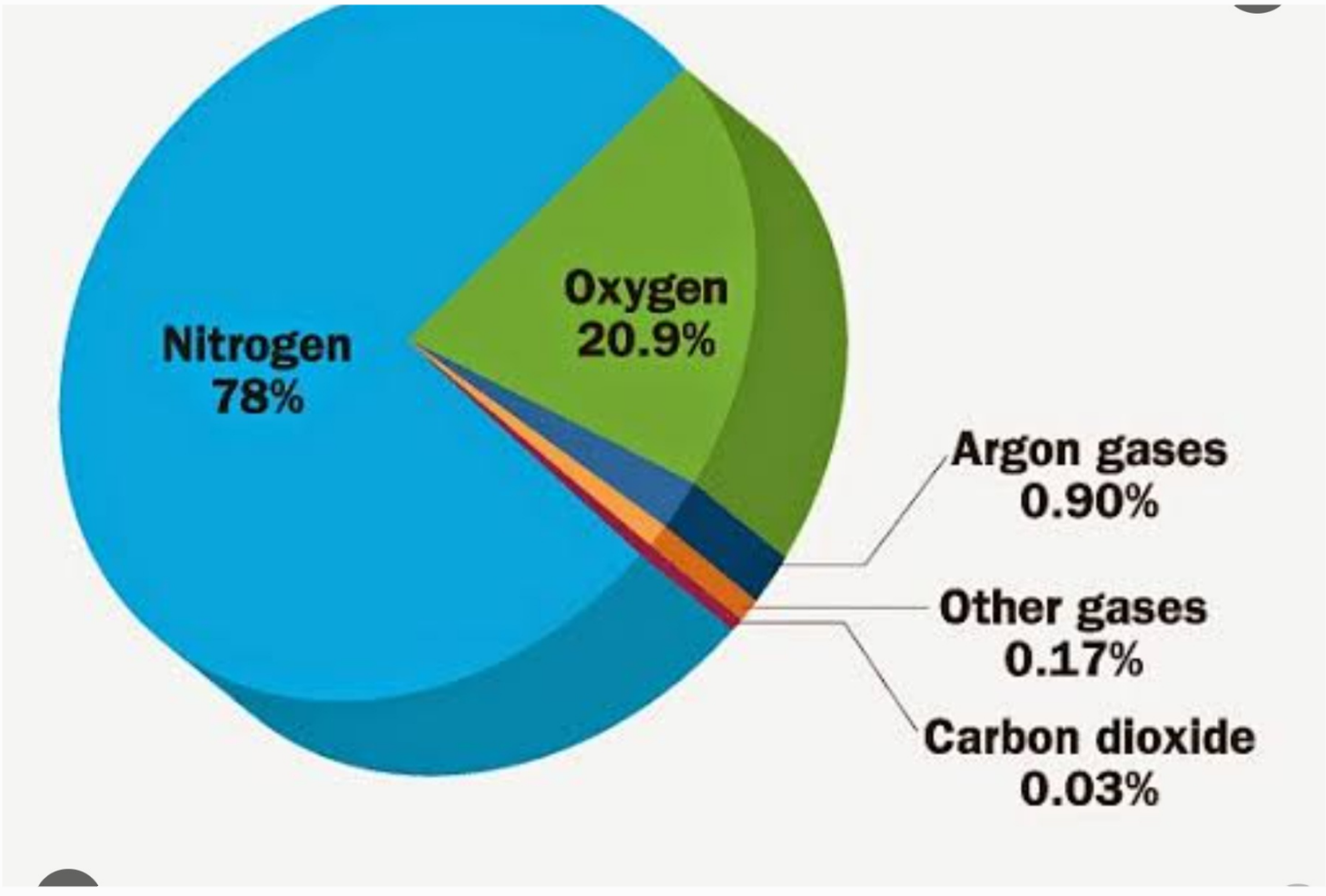
Criteria	Direct Sources	Indirect Sources
Definition	Data obtained by direct measurement or observation of the atmosphere.	Data inferred from natural records or other indicators related to the atmosphere.
Usages	Weather forecasting, climate monitoring	Studying past climate changes, understanding ancient atmospheres
Data Collection Devices	**Thermometer**, **barometer**, **anemometer**, satellites	**Ice cores**, **seismographs**, **magnetic field detectors**

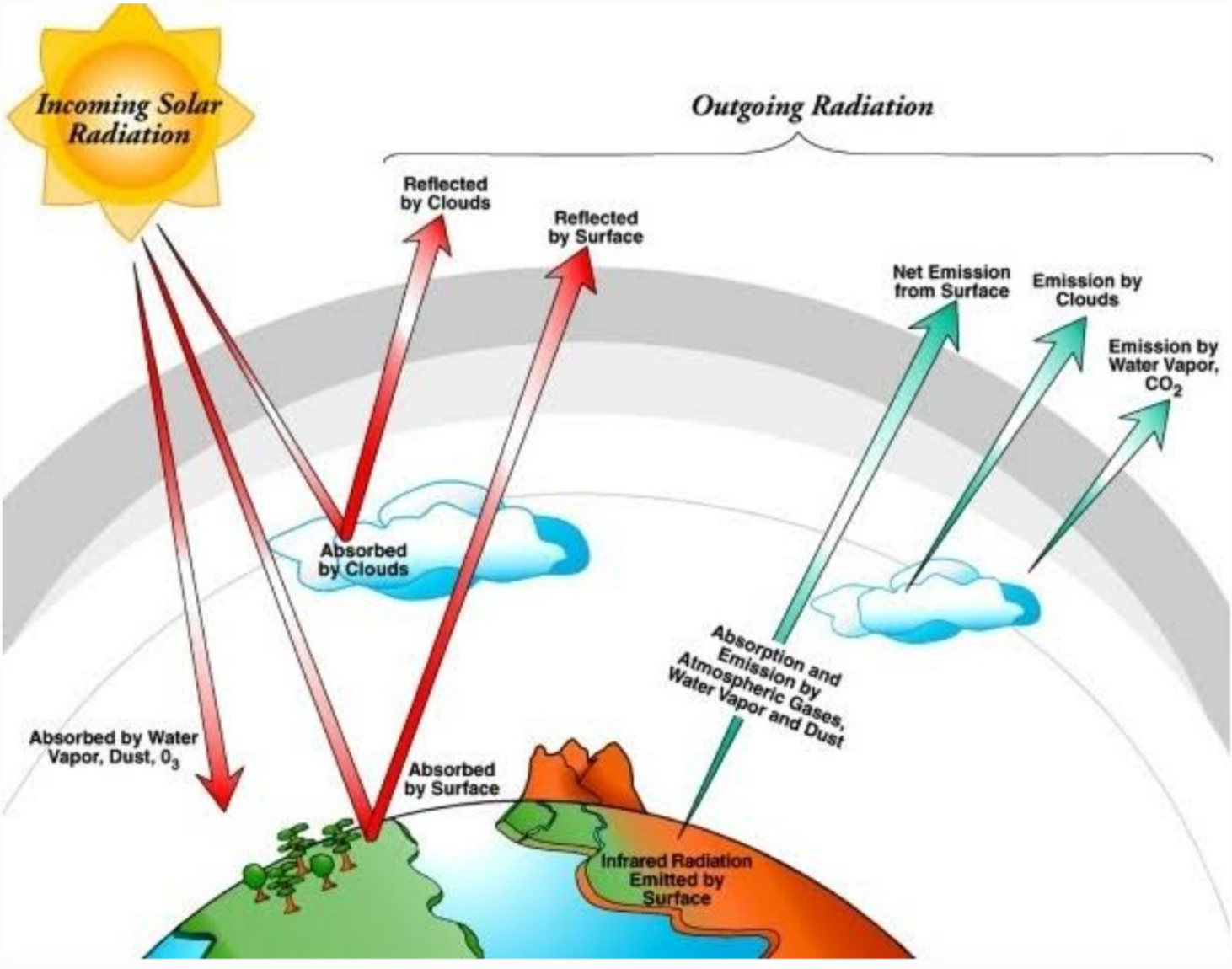

Escapes
Escapes
Hydrogen
Hydrogen
Water
Nitrogen
Oxygen
To
atmosphere
Water
Carbon dioxide
Oxygen
Photosynthesis
Volcano
To oceans
Molten rock

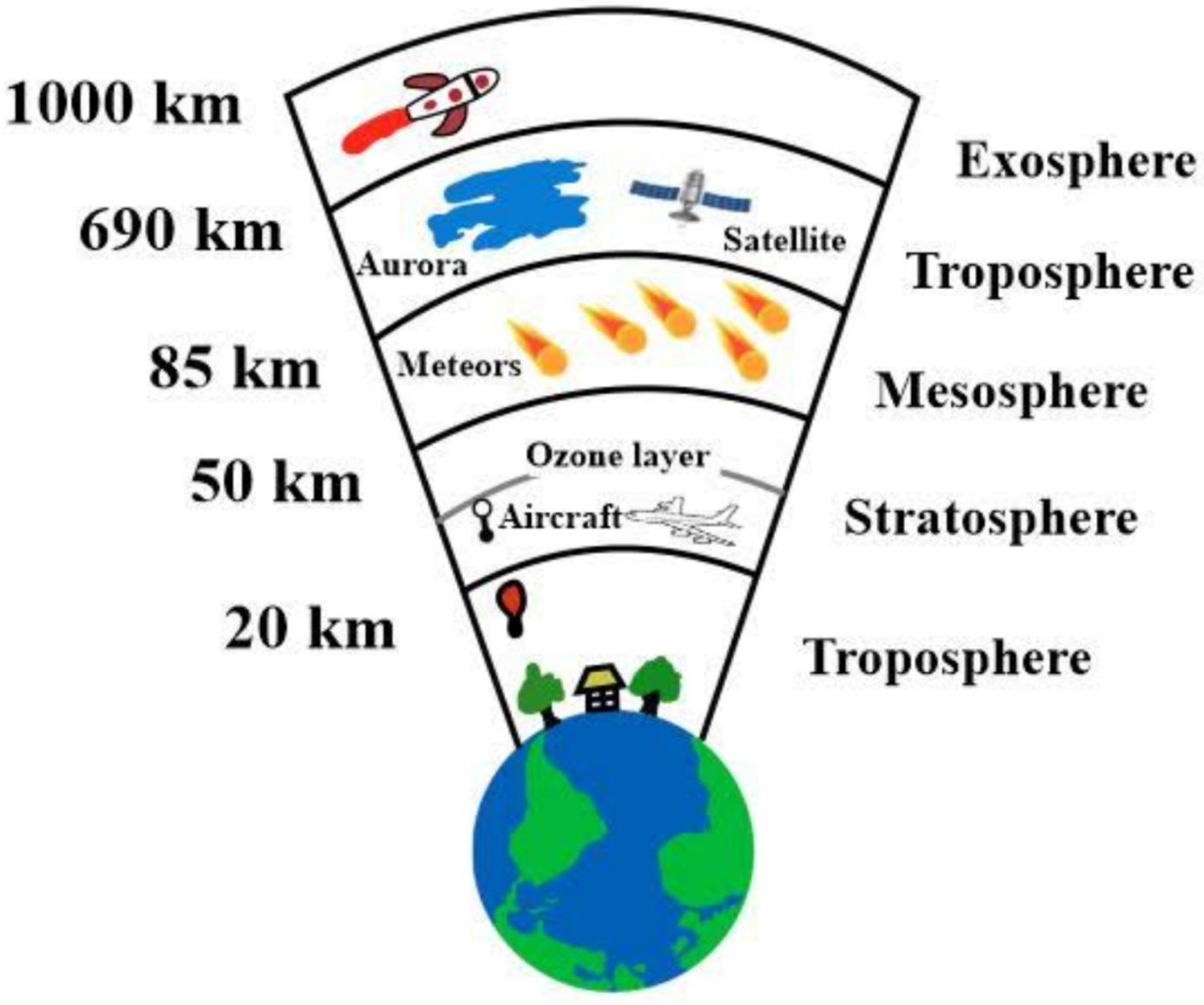
- One of the main components of Earth's interdependent physical systems is the atmosphere. An atmosphere is made of the layers of gases surrounding a planet or other celestial body.

- **Composition:**
  - Earth's atmosphere is composed of about 78% nitrogen, 21% oxygen, and 1% other gases.
    - Nitrogen (N_2): It is the most plentiful gas in the air. It is one of the primary nutrients critical for the survival of all living organisms.
    - Oxygen (O_2): 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 (CO_2): It is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels.

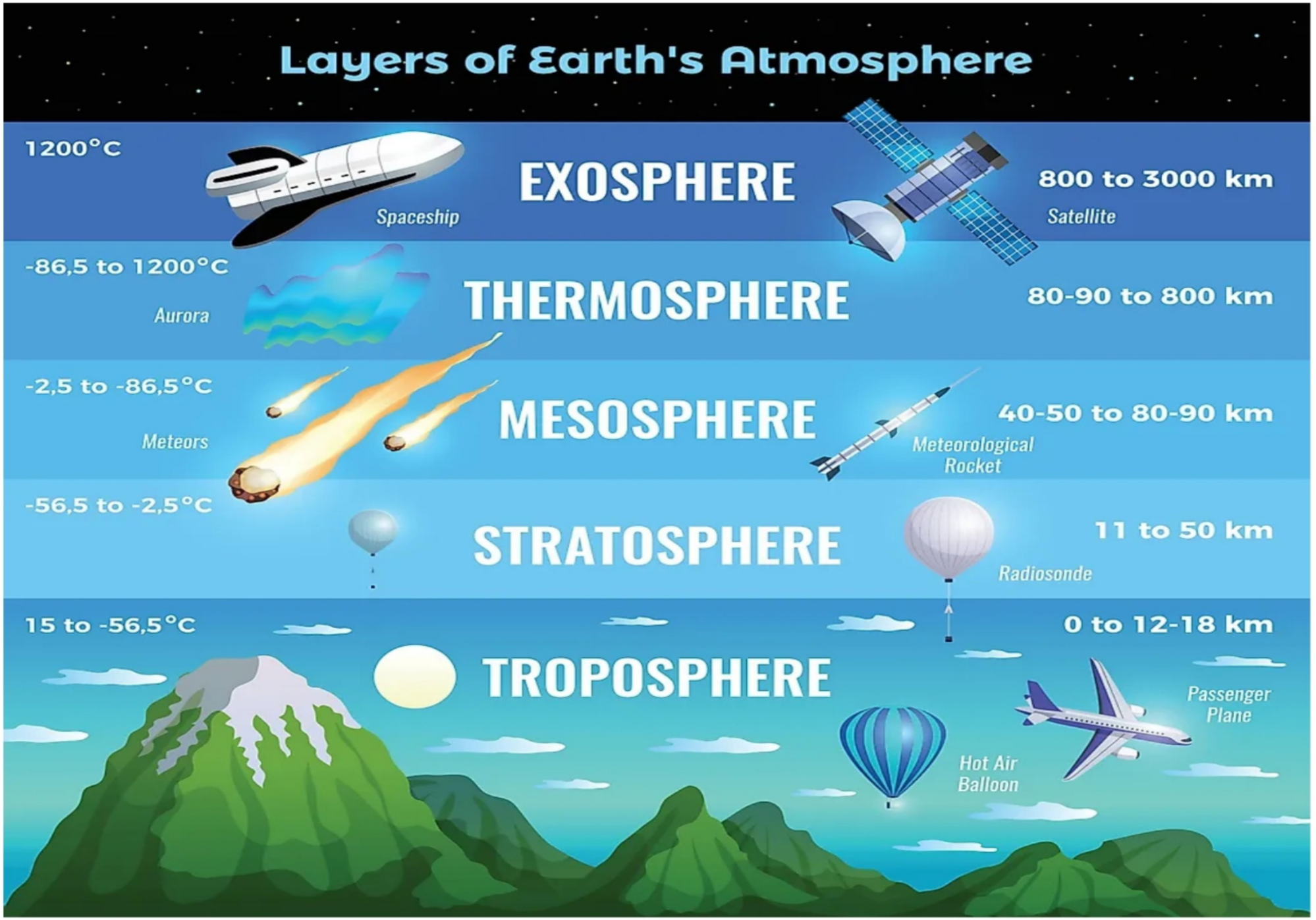


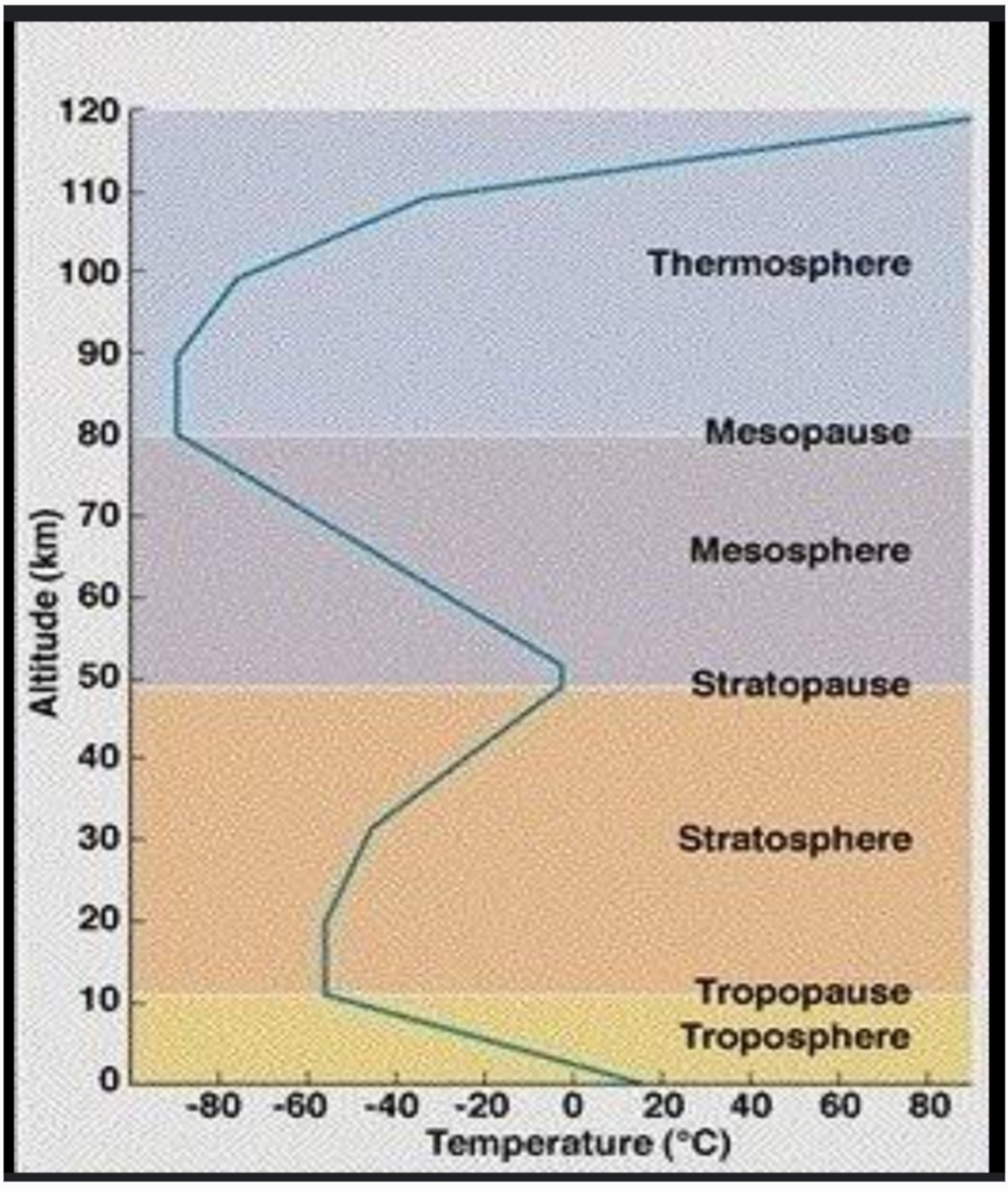

Nitrogen
78%
Oxygen
20.9%
Argon gases
0.90%
Other gases
0.17%
Carbon dioxide
0.03%


Incoming Solar Radiation
Outgoing Radiation
Reflected by Clouds
Reflected by Surface
Net Emission from Surface
Emission by Clouds
Emission by Water Vapor, CO_2
Absorbed by Clouds
Absorption and Emission by Atmospheric Gases, Water Vapor and Dust
Absorbed by Water Vapor, Dust, 0_3
Absorbed by Surface
Infrared Radiation Emitted by Surface


1000 km
690 km
85 km
50 km
20 km
Exosphere
Troposphere
Mesosphere
Stratosphere
Troposphere
Aurora
Satellite
Meteors
Ozone layer
Aircraft

Layers of Earth's Atmosphere




120
110
100
90
80
70
60
50
40
30
20
10
0
Altitude (km)
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
-80
-60
-40
-20
0
20
40
60
80
Temperature (°C)

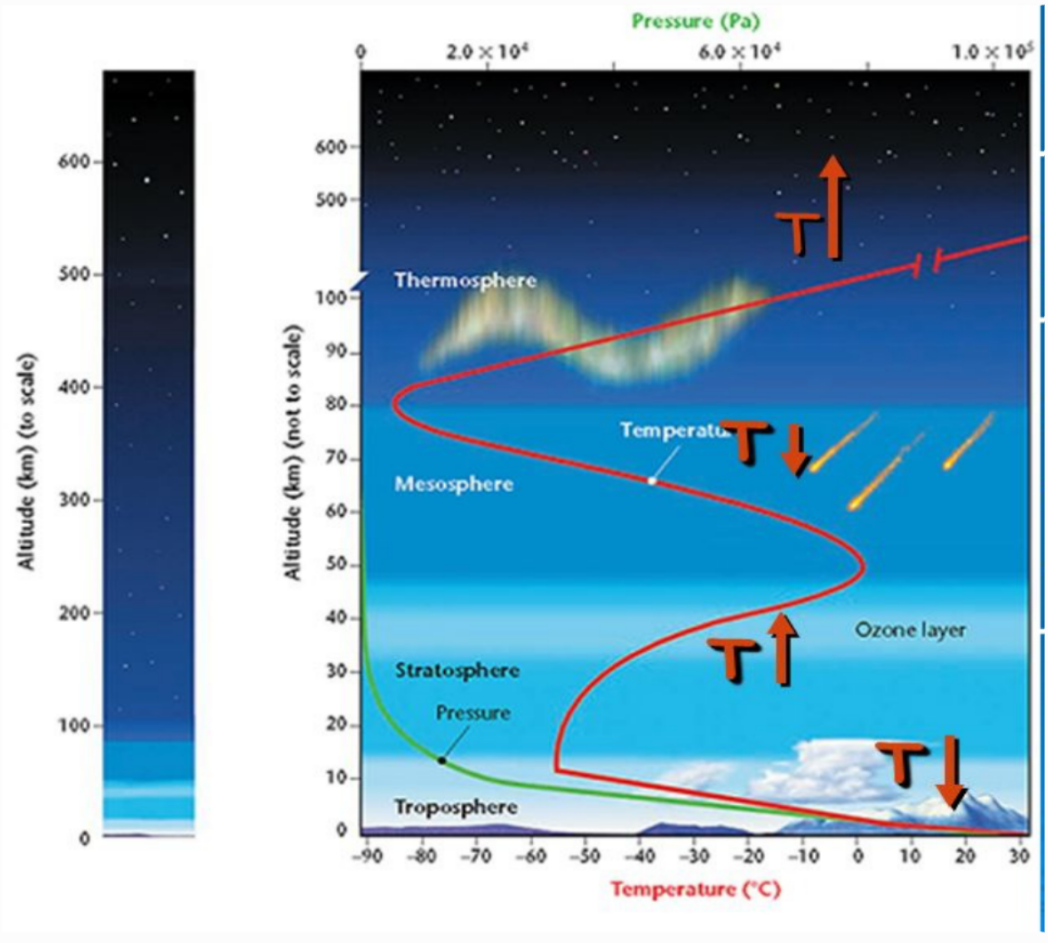
There are five layers in the structure of the atmosphere depending upon temperature.

These layers are:

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere
- Exosphere

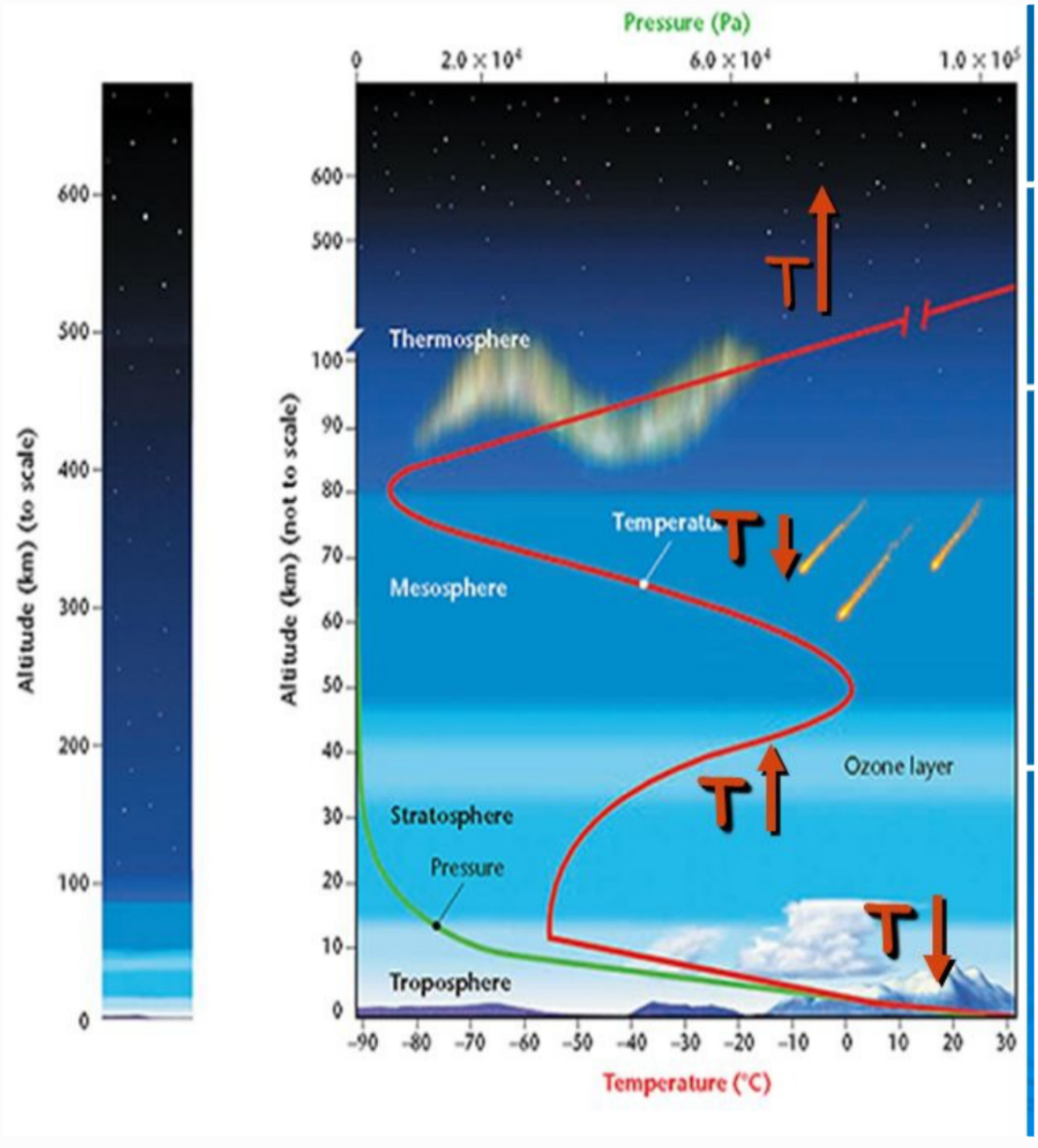
Troposphere

- It is considered as the lowest layer of Earth's atmosphere.
- The troposphere starts at the surface of the earth and goes up to a height of 8 km (poles) to 18 km (equator). The main reason for higher height at the equator is due to the presence of hot convection currents that push the gases upward.
- All kinds of weather changes occur within this layer.
- This layer has water vapour and mature particles.
- Temperature decreases with increasing height of atmosphere at the rate of 1 degree Celsius for every 165 m of height. This is called the **Normal lapse rate.**
- Tropopause, the transitional zone, separates the Troposphere and Stratosphere.


Pressure (Pa)
0
2.0 × 10⁴
6.0 × 10⁴
1.0 × 10⁵
Altitude (km) (to scale)
Altitude (km) (not to scale)
Thermosphere
Mesosphere
Stratosphere
Troposphere
Ozone layer
Pressure
Temperature (°C)
−90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30

Stratosphere

- It is the second layer of the atmosphere found above the troposphere.
- It extends up to a height of 50 km from the earth's surface.
- This layer is very dry as it contains little water vapour.
- This layer provides some advantages for flight because it is above stormy weather and has steady, strong, horizontal winds.
- The ozone layer is found in this layer.
- The ozone layer absorbs UV rays and safeguards Earth from harmful radiation.
- Stratopause separates Stratosphere and Mesosphere.


Pressure (Pa)
0
2.0 × 10⁴
6.0 × 10⁴
1.0 × 10⁵
Altitude (km) (to scale)
Altitude (km) (not to scale)
600
500
400
300
200
100
0
90
80
70
60
50
40
30
20
10
Thermosphere
Temperature
Mesosphere
Ozone layer
Stratosphere
Pressure
Troposphere
T
−90
−80
−70
−60
−50
−40
−30
−20
−10
10
20
30
Temperature (°C)

Mesosphere

- The Mesosphere is found above the stratosphere.
- It is the coldest of the atmospheric layers.
- The mesosphere starts at 50 km above the surface of the Earth and goes up to 80 km.
- The temperature drops with altitude in this layer.
- By 80 km it reaches -100 degrees Celsius.
- Meteors burn up in this layer.
- The upper limit is called Mesopause which separates Mesosphere and Thermosphere.

Thermosphere

- This layer is found above Mesopause from 80 to 400 km.
- Radio waves that are transmitted from the earth are reflected by this layer.
- The temperature starts increasing again with increasing height in this layer.
- Aurora and satellites occur in this layer.

Ionosphere

- The lower Thermosphere is called the Ionosphere.
- The ionosphere consists of electrically charged particles known as ions.
- This layer is defined as the layer of the atmosphere of Earth that is ionized by cosmic and solar radiation.
- It is positioned between 80 and 400 km above the Mesopause.

Exosphere

- It is the outermost layer of the atmosphere.
- The zone where molecules and atoms escape into space is mentioned as the exosphere.
- It extends from the top of the thermosphere up to 10,000 km.

WORLD MAP