MODULE 1 TOPIC 1

Earth's Atmosphere: Composition, Climate & Weather

Astronauts aboard the International Space Station took this image showing Earth's atmosphere and moon on July 31, 2011.

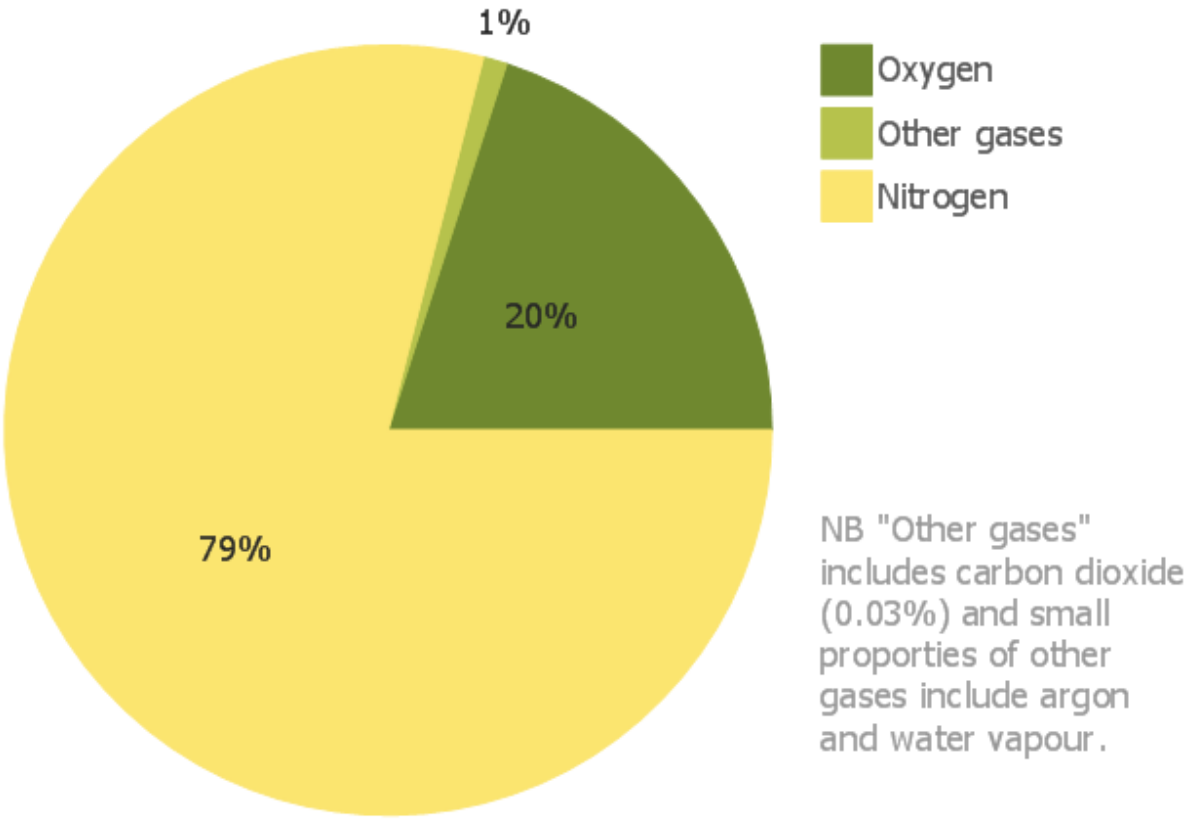
(Image: © ISS Crew Earth Observations Experiment and Image Science & Analysis Laboratory/Johnson Space Center.)

Earth is the only planet in the solar system with an atmosphere that can sustain life. The blanket of gases not only contains the air that we breathe but also protects us from the blasts of heat and radiation emanating from the sun. It warms the planet by day and cools it at night. Earth's atmosphere is about 300 miles (480 kilometers) thick, but most of it is within 10 miles (16 km) the surface. Air pressure decreases with altitude. At sea level, air pressure is about 14.7 pounds per

square inch (1 kilogram per square centimeter). At 10,000 feet (3 km), the air pressure is 10 pounds per square inch (0.7 kg per square cm).

There is also less oxygen to breathe.

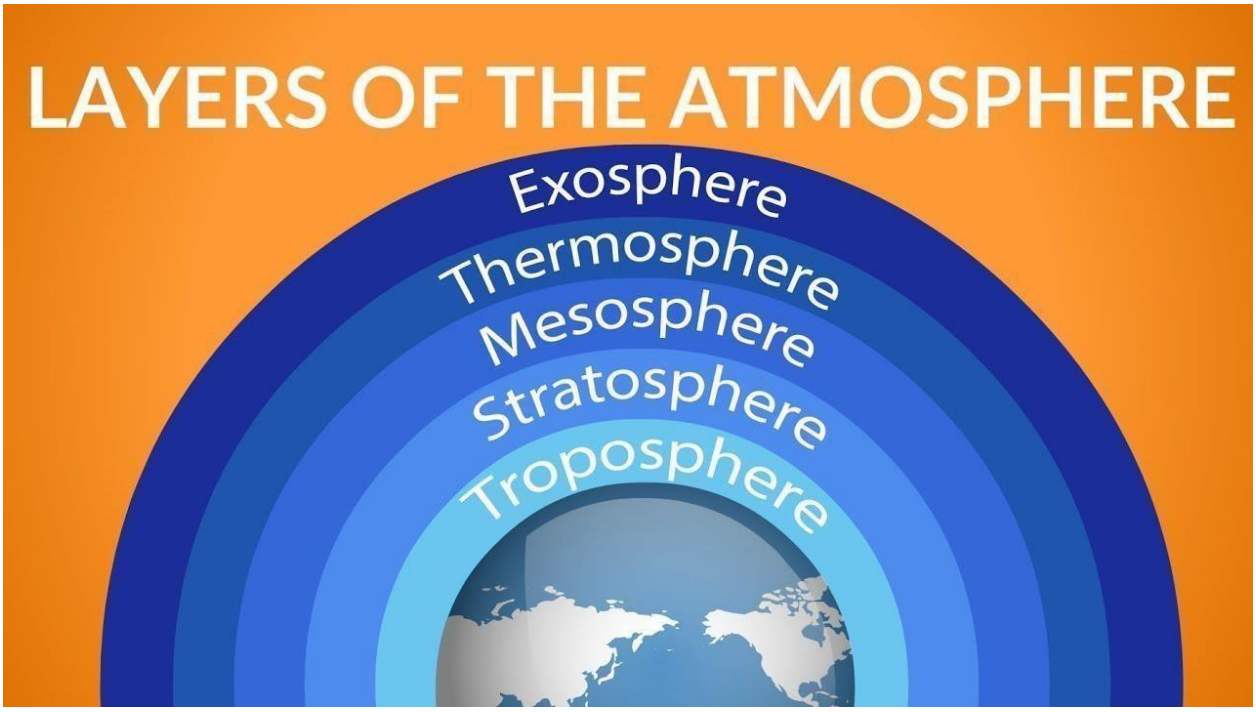
Composition of air



According to NASA, the gases in Earth's atmosphere include:

- Nitrogen — 78 percent
- Oxygen — 21 percent
- Argon — 0.93 percent
- Carbon dioxide — 0.04 percent
- Trace amounts of neon, helium, methane, krypton and hydrogen, as well as water vapor

The different layers of the atmosphere



The atmosphere can be divided into layers based on its temperature, as shown in the figure below.

These layers are the troposphere, the stratosphere, the mesosphere and the thermosphere.

A further region, beginning about 500 km above the Earth's surface, is called the exosphere.

The red line on the figure below shows how temperature varies with height (the temperature scale is given along the bottom of the diagram). The scale on the right shows the pressure. For example, at a height of 50 km, the pressure is only about one thousandth of the pressure at the ground.

The Troposphere

This is the lowest part of the atmosphere - the part we live in. It contains most of our weather - clouds, rain, snow. In this part of the atmosphere the temperature gets colder as the distance

above the earth increases, by about 6.5°C per kilometre. The actual change of temperature with height varies from day to day, depending on the weather.

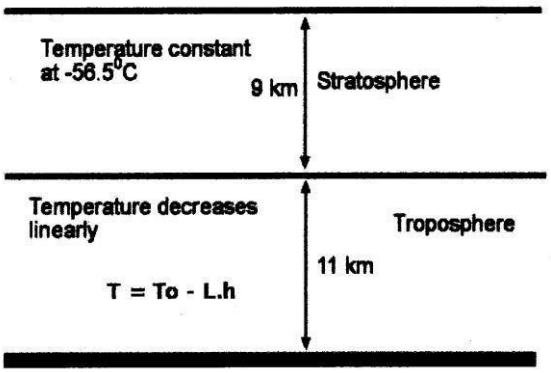
The troposphere contains about 75% of all of the air in the atmosphere, and almost all of the water vapour (which forms clouds and rain). The decrease in temperature with height is a result of the decreasing pressure. If a parcel of air moves upwards it expands (because of the lower pressure).
When air expands it cools. So air higher up is cooler than air lower down.

The lowest part of the troposphere is called the boundary layer. This is where the air motion is determined by the properties of the Earth's surface. Turbulence is generated as the wind blows over the Earth's surface, and by thermals rising from the land as it is heated by the sun. This turbulence redistributes heat and moisture within the boundary layer, as well as pollutants and other constituents of the atmosphere.

The top of the troposphere is called the tropopause. This is lowest at the poles, where it is about 7 - 10 km above the Earth's surface. It is highest (about 17 - 18 km) near the equator.

The Stratosphere

This extends upwards from the tropopause to about 50 km. It contains much of the ozone in the atmosphere. The increase in temperature with height occurs because of absorption of ultraviolet (UV) radiation from the sun by this ozone. Temperatures in the stratosphere are highest over the summer pole, and lowest over the winter pole.



By absorbing dangerous UV radiation, the ozone in the stratosphere protects us from skin cancer and other health damage. However chemicals (called CFCs or freons, and halons) which were once used in refrigerators, spray cans and fire extinguishers have reduced the amount of ozone in the stratosphere, particularly at polar latitudes, leading to the so-called "Antarctic ozone hole".

Now humans have stopped making most of the harmful CFCs we expect the ozone hole will eventually recover over the 21st century, but this is a slow process.

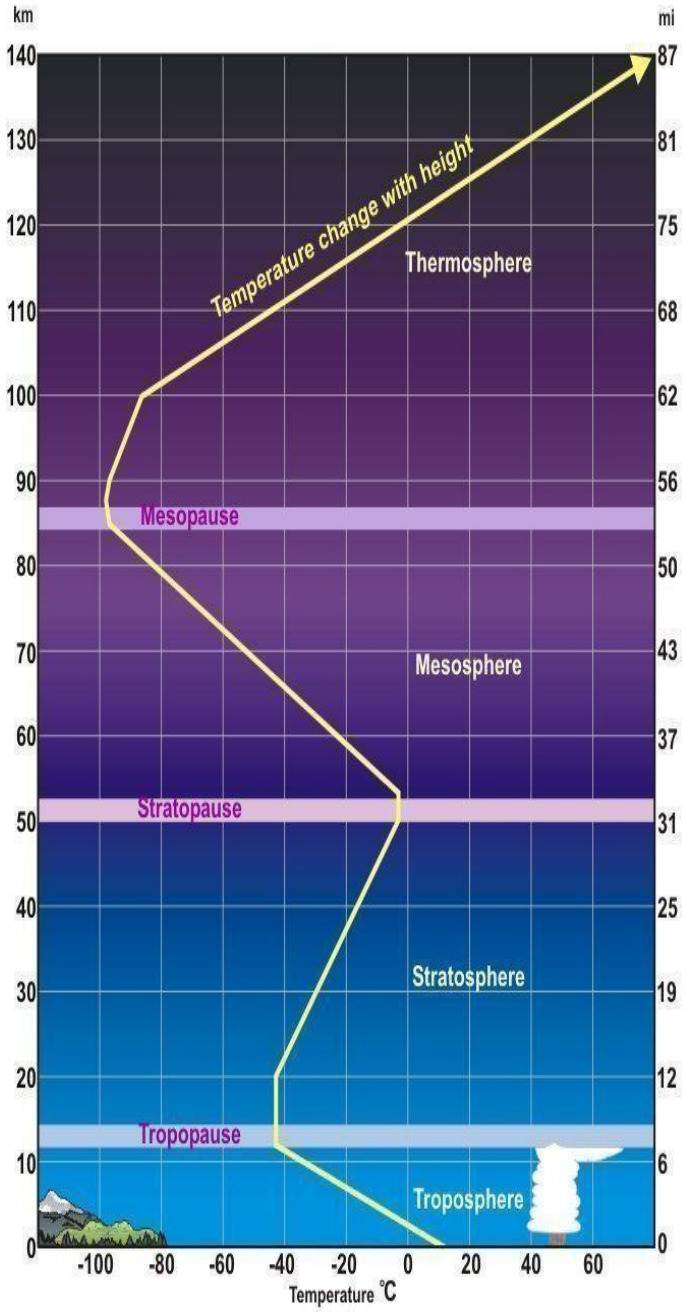
The Mesosphere

The region above the stratosphere is called the mesosphere. Here the temperature again decreases with height, reaching a minimum of about -90°C at the "mesopause".

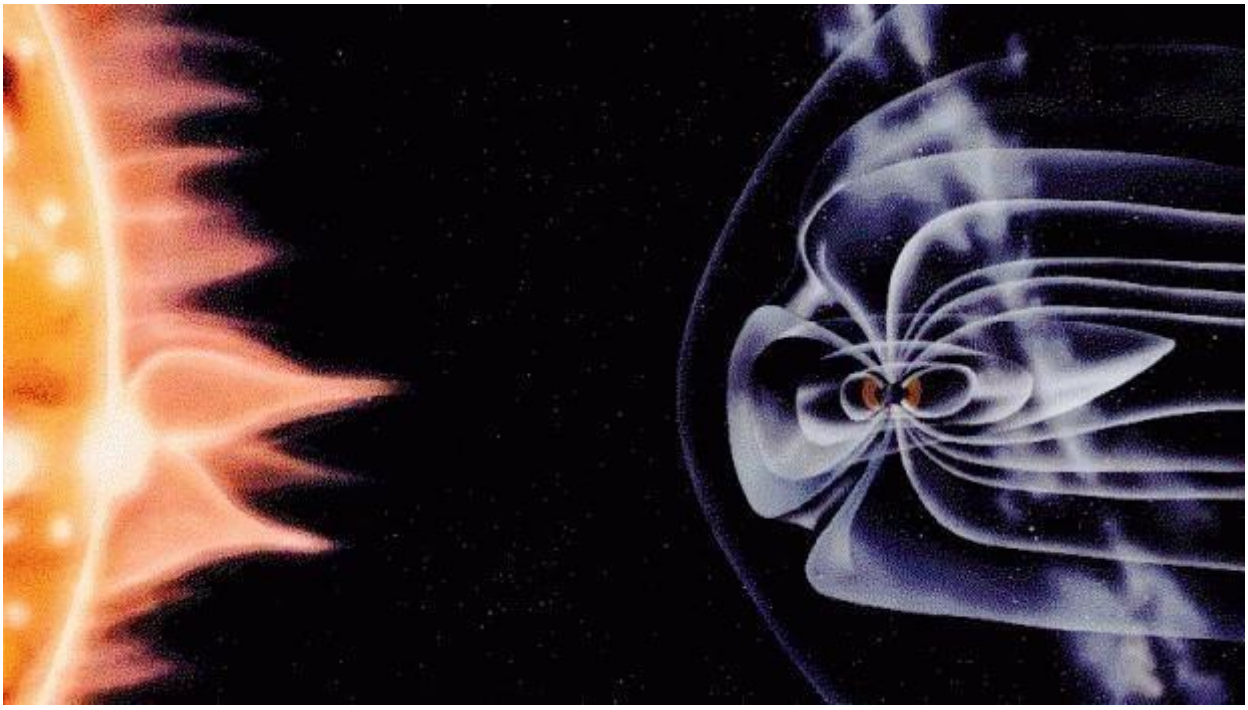
The Thermosphere and Ionosphere

The Exosphere

The region above about 500 km is called the exosphere. It contains mainly oxygen and hydrogen atoms, but there are so few of them that they rarely collide - they follow "ballistic" trajectories under the influence of gravity, and some of them escape right out into space.



The Magnetosphere



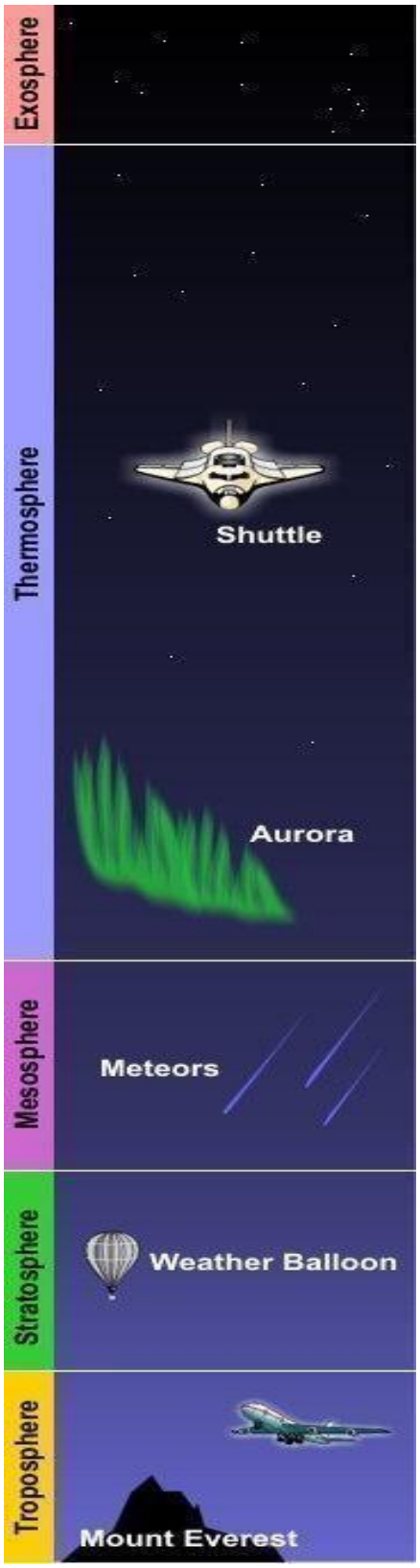
The earth behaves like a huge magnet. It traps electrons (negative charge) and protons (positive), concentrating them in two bands about 3,000 and 16,000 km above the globe - the Van Allen "radiation" belts. This outer region surrounding the earth, where charged particles spiral along the magnetic field lines, is called the magnetosphere.

Earth, Venus and Mars

To better understand the formation and composition of Earth, scientists sometimes compare our planet with Venus and Mars. All three of these planets are rocky in nature and are part of the inner solar system, meaning that they are in between the sun and the asteroid belt.

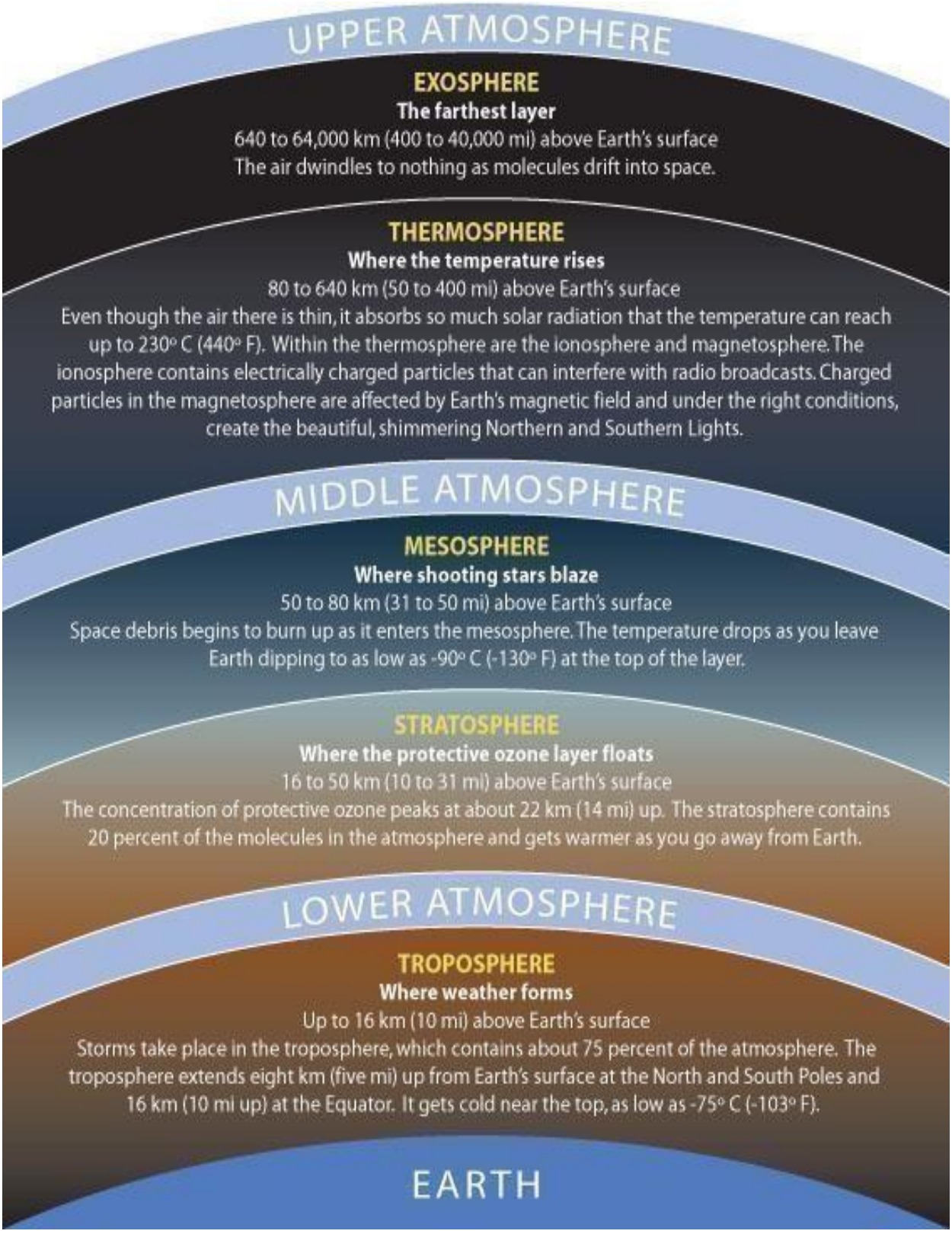
Venus has an almost fully carbon dioxide atmosphere, with traces of nitrogen and sulfuric acid. The planet, however, also has a runaway greenhouse effect on its surface. Spacecraft have to be heavily reinforced to survive the crushing pressure (90 times heavier than Earth), and the ovenlike temperatures (872 Fahrenheit or 467 Celsius), found at its surface. The clouds are also so thick that the surface is invisible in visible light. Because not much sun reaches the surface, this means that Venus has no significant seasonal temperature changes.

Mars also has a mostly carbon dioxide atmosphere, with traces of nitrogen, argon, oxygen, carbon monoxide and some other gases. On this planet, the atmosphere is about 100 times thinner than



Earth's — a very different situation from the ancient past, when geological evidence shows that water used to flow on the surface more than 4.5 billion years ago. Scientists suggest that the Martian atmosphere may have thinned over time, either because the sun stripped away the lighter molecules in the atmosphere, or because a huge impact by an asteroid or comet catastrophically stripped the atmosphere. Mars undergoes temperature swings influenced by how much sunlight reaches the surface, which also affects its polar ice caps (another great influence on the atmosphere.) Scientists routinely compare small, rocky exoplanets to Earth, Venus and Mars to get a better sense of their habitability. The routinely accepted definition of "habitability" is that a planet is close enough to the star for liquid water to exist on its surface. Too far, and the water turns icy; too close, and the water evaporates. However, habitability not only depends on the star-planet distance, but also the planet's atmosphere, the star's variability, and other

factors.


UPPER ATMOSPHERE
EXOSPHERE
The farthest layer
640 to 64,000 km (400 to 40,000 mi) above Earth's surface
The air dwindles to nothing as molecules drift into space.
THERMOSPHERE
Where the temperature rises
80 to 640 km (50 to 400 mi) above Earth's surface
Even though the air there is thin, it absorbs so much solar radiation that the temperature can reach up to 230° C (440° F). Within the thermosphere are the ionosphere and magnetosphere. The ionosphere contains electrically charged particles that can interfere with radio broadcasts. Charged particles in the magnetosphere are affected by Earth's magnetic field and under the right conditions, create the beautiful, shimmering Northern and Southern Lights.
MIDDLE ATMOSPHERE
MESOSPHERE
Where shooting stars blaze
50 to 80 km (31 to 50 mi) above Earth's surface
Space debris begins to burn up as it enters the mesosphere. The temperature drops as you leave Earth dipping to as low as -90° C (-130° F) at the top of the layer.
STRATOSPHERE
Where the protective ozone layer floats
16 to 50 km (10 to 31 mi) above Earth's surface
The concentration of protective ozone peaks at about 22 km (14 mi) up. The stratosphere contains 20 percent of the molecules in the atmosphere and gets warmer as you go away from Earth.
LOWER ATMOSPHERE
TROPOSPHERE
Where weather forms
Up to 16 km (10 mi) above Earth's surface
Storms take place in the troposphere, which contains about 75 percent of the atmosphere. The troposphere extends eight km (five mi) up from Earth's surface at the North and South Poles and 16 km (10 mi up) at the Equator. It gets cold near the top, as low as -75° C (-103° F).
EARTH

SUMMARY OF ATMOSPHERE

1. The troposphere is the lowest layer of our atmosphere. Starting at ground level, it extends upward to about 10 km (6.2 miles or about 33,000 feet) above sea level. We humans live in the troposphere, and nearly all weather occurs in this lowest layer. Most clouds appear here, mainly because 99% of the water vapor in the atmosphere is found in the troposphere.

Air pressure drops, and temperatures get colder, as you climb higher in the troposphere.

2. The stratosphere is a layer of Earth's atmosphere. It is the second layer of the atmosphere as you go upward. The troposphere, the lowest layer, is right below the stratosphere. The next higher layer above the stratosphere is the mesosphere.

3. The mesosphere is a layer of Earth's atmosphere. The mesosphere is directly above the stratosphere and below the thermosphere. It extends from about 50 to 85 km (31 to 53 miles) above our planet.

4. Temperature decreases with height throughout the mesosphere. The coldest temperatures in

   Earth's atmosphere, about -90° C (-130° F), are found near the top of this layer.

5. The thermosphere is the layer in the Earth's atmosphere directly above the mesosphere and below the exosphere. Within this layer of the atmosphere, ultraviolet radiation causes photoionization/photodissociation of molecules, creating ions; the thermosphere thus constitutes the larger part of the ionosphere.

6. The ionosphere is not a distinct layer like the others mentioned above. Instead, the ionosphere is a series of regions in parts of the mesosphere and thermosphere where

highenergy radiation from the Sun has knocked electrons loose from their parent atoms and molecules. 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.

7. The exosphere is the uppermost region of Earth's atmosphere as it gradually fades into the vacuum of space. Air in the exosphere is extremely thin - in many ways it is almost the same as the airless void of outer space.
8. The magnetosphere is the region of space surrounding Earth where the dominant magnetic field is the magnetic field of Earth, rather than the magnetic field of interplanetary space.

   The magnetosphere is formed by the interaction of the solar wind with Earth’s magnetic field.