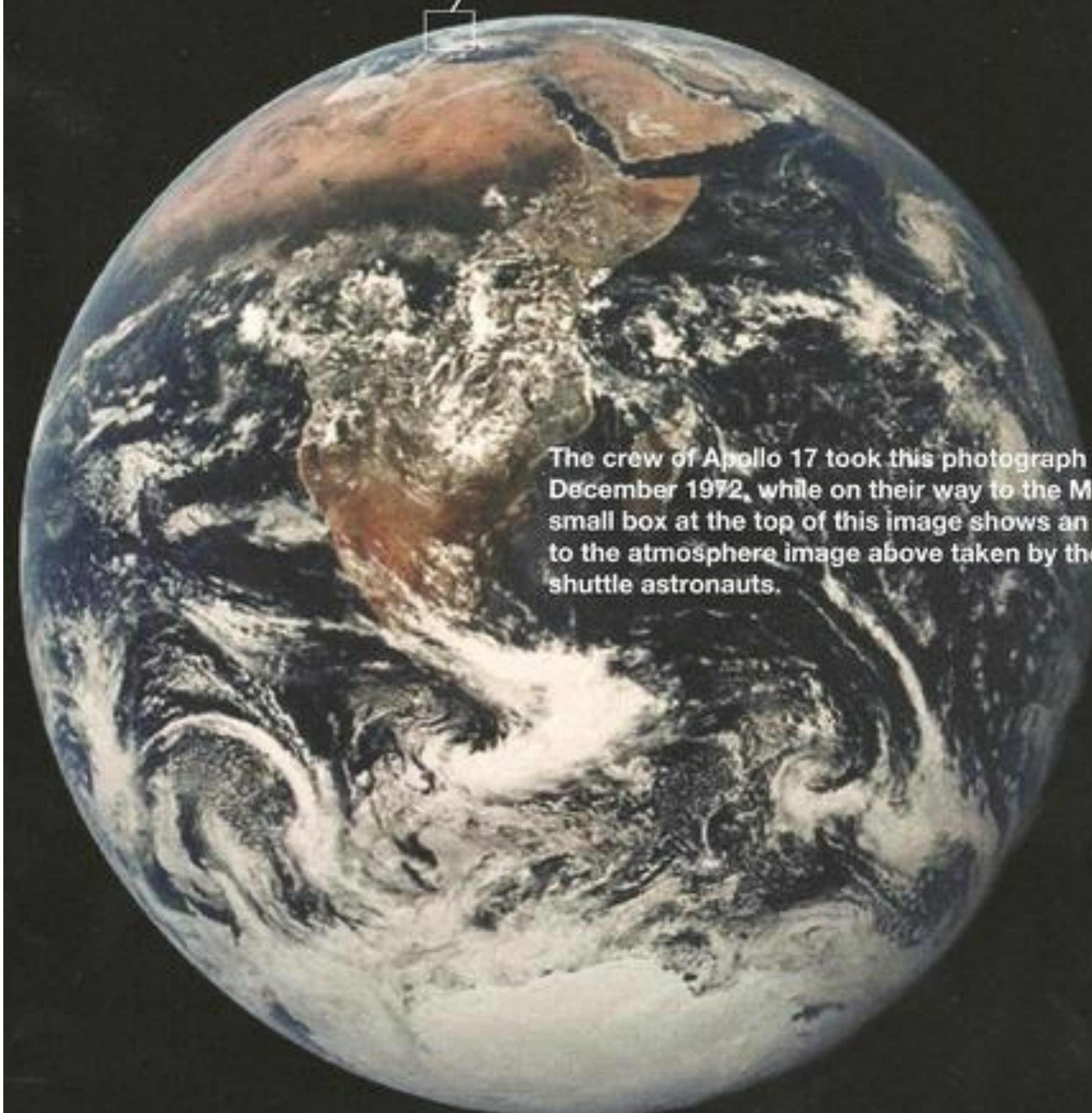
A Thin Blue Veil

Space-shuttle astronauts took this photo while orbiting Earth. You can see a side view of Earth's atmosphere. The black bumps pushing into the troposphere are tall cumulus clouds.



The crew of Apollo 17 took this photograph of Earth in December 1972, while on their way to the Moon. The small box at the top of this image shows an area equal to the atmosphere image above taken by the space-shuttle astronauts.

It is cold in deep space. The temperature is in the neighborhood of –270°C. That's nearly 200°C colder than it has ever been on Earth. Near stars, like the Sun, it's hot—outlandishly hot—reaching thousands of degrees. There are, however, a few places here and there in the universe where the temperature is between the extremes. Earth is one of those places. In fact, the average temperature on Earth is just about the temperature of Baby Bear's porridge—not too hot and not too cold, but just right.

On a typical day, the temperature range on our planet is only about 100°C, from maybe 45°C in the hottest place to –55°C at one of the poles. The measured extremes are 58°C in El Azizia, Libya, recorded on September 13, 1922, and –89°C in Vostok, Antarctica, on July 21, 1983. That's a range of temperature on Earth of 147°C.

It's not only because we are at the right distance from the Sun that Earth has tolerable temperatures. Earth is wrapped in a blanket of gases—the atmosphere. Earth's atmosphere keeps the temperature within a narrow range that is suitable for life.

From space, Earth's atmosphere looks like a thin blue veil. Some people like to think of the atmosphere as an ocean of air covering Earth. The depth of this "ocean" is about 600 kilometers (km). The atmosphere is densest right at the bottom where it rests on Earth's surface. It gets thinner and thinner (less dense) as you move away from Earth's surface. There is no real boundary between the atmosphere and space. The air just gets thinner and thinner until it disappears.

Imagine a column of air that starts on Earth's surface and extends up 600 km to the top of the atmosphere. Scientists have discovered several distinct layers in this column of air. Each layer has a different temperature. Here's how it stacks up.

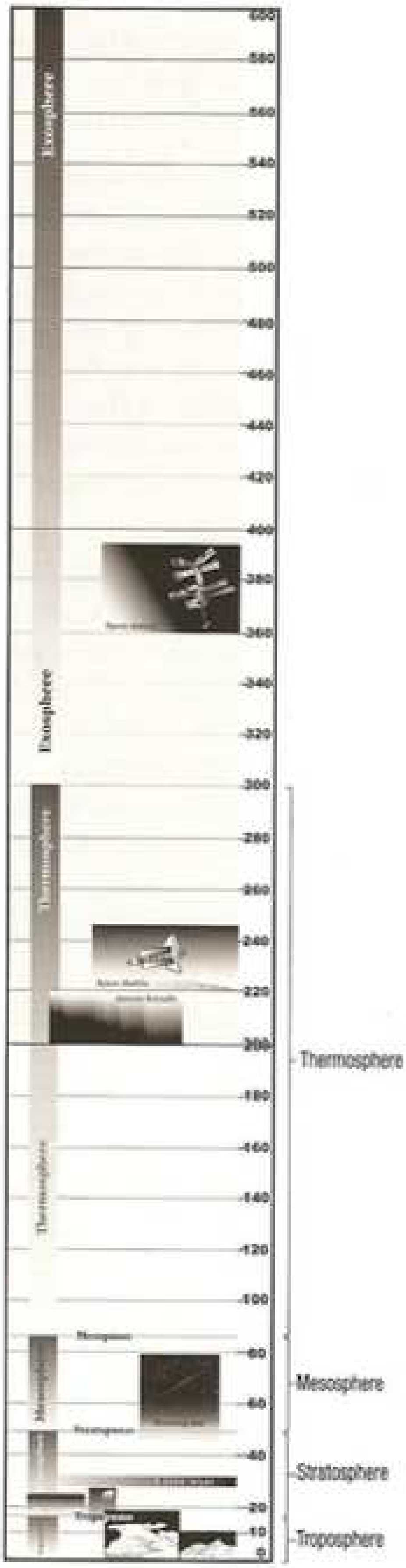
The layer we live in is the **troposphere.** It starts at Earth's surface and extends upward for 9–20 km. Its thickness depends on the season and where you are on Earth. Over the warm equator, the troposphere is a little thicker than it is over the polar regions, where the air is colder. It also thickens during the summer and thins during the winter. A good average thickness for the troposphere is 10 km.

This ground-floor layer contains most of the organisms, dust, water vapor, and clouds found in the entire atmosphere. For that matter, it contains most of the air as well. And, most important, weather happens in the troposphere. The troposphere is where the action is. This is where differences in air temperature, humidity (moisture), pressure, and wind occur.

These properties of temperature, humidity, pressure, and wind are called **weather factors.** Meteorologists launch weather balloons twice each day to monitor weather factors. The balloons float up through the troposphere to about 18 km. Weather factors will be investigated in detail as we continue to study weather.

The troposphere is the thinnest layer—only about 2% of the depth of the atmosphere. It is the densest layer, however, containing four-fifths (80%) of the total mass of the atmosphere.

Earth's surface (land and water) absorbs heat from the Sun and warms the air above it. Because air in the troposphere is heated



mostly by Earth's surface, the air is warmest close to the ground. The air temperature drops as you go higher. At its upper limit, the temperature of the troposphere is about –60°C. The average temperature of the troposphere is about 25°C.

Mount Everest, located in Nepal and Tibet, is the highest landform on Earth, rising 8.848 km into the troposphere. The air temperature at the top of the mountain is well below freezing most of the time. There is also less air to breathe at the top of Mount Everest. Climbers usually bring oxygen along to help them survive the thin air.

The **stratosphere** is the layer above the troposphere. It is 10–50 km above Earth's surface and contains almost no moisture or dust. It does, however, contain a layer of ozone (O_3), a form of oxygen, that absorbs high-energy ultraviolet (UV) radiation from the Sun. The temperature stays cold until you reach the upper reaches of the stratosphere, where energy absorption by ozone warms the air to about 0°C.

The jet stream, a fast-flowing river of wind, travels generally west to east in the region between the lower stratosphere and the upper troposphere. Many military and commercial jet aircraft take advantage of the jet stream when flying from west to east.

The **mesosphere** is above the stratosphere, 50–80 km above Earth's surface. The temperature plunges again, reaching its coldest temperature of around –90°C in the upper mesosphere. This is the layer in which meteors burn up while entering Earth's atmosphere, producing what we call shooting stars.

Beyond the mesosphere, 80–300 km above Earth, is the **thermosphere.** The thermosphere is the least-understood layer of the atmosphere and the most difficult to measure. The air is extremely thin. The thermosphere is the region of the atmosphere that is first heated by the Sun. A small amount of energy coming from the Sun can result in a large temperature change. When the Sun is extra active with sunspots or flares, the temperature of the thermosphere can surge up to 1500°C or higher!

Within the thermosphere is a layer noted for its chemistry, the **ionosphere.** The ionosphere contains a large number of electrically charged ions. Ions form when intense radiation from the Sun hits atoms and molecules. The ionosphere is responsible for the aurora borealis, or northern lights, and the aurora australis, or southern lights.

The identification of these four layers is based on temperature. There are no sharp boundaries or abrupt changes in gas composition between them. As average temperatures change with the seasons, the boundaries between layers may move up or down a little.

Beyond the thermosphere, Earth's atmosphere makes a transition into space. This area is the **exosphere** where atoms and molecules escape into space. It extends from 300 to 600 km above Earth. In this region, the temperature plunges to the extreme –270°C of outer space, and the concentration of atmospheric gases fades to nothing.

That 600-km column of air pushes down on the surface of Earth with a lot of force. We call the force **air pressure,** or **atmospheric pressure.** We are not aware of it because we are adapted to live under all that pressure, but there is a mass of about 1 kilogram (kg) pushing down on every square centimeter of surface on Earth. Your head has a surface area of about 150 cm^2. This means you have about 150 kg of air parked on your head. That's about like having a kitchen stove or a motorcycle pushing down on your head all the time!

Another way to look at it...if all the air were replaced with solid gold, the entire planet would be covered by a layer of gold a little more than half a meter deep. The mass of the entire atmosphere is about equal to half a meter of gold, but the atmosphere is much more valuable.

Think Questions

1. How is Earth's atmosphere like an ocean? How is it unlike an ocean?
2. Why do you think airplanes don't fly high in the stratosphere?