Atmospheric Gases Activity Teacher Guide

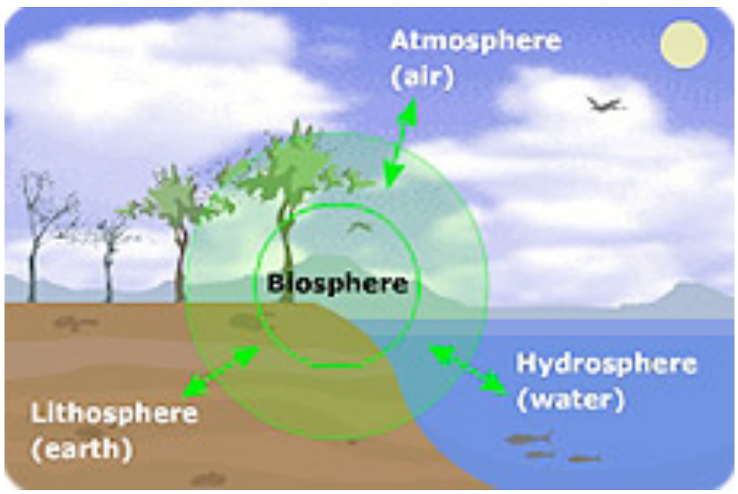
Driving Question: What is our atmosphere made of?

In this activity your students will:
1. Explore the variety and ratio of compounds and elements that make up the Earth's atmosphere.
2. Understand volumetric measurements of gases in the atmosphere.
3. Visually depict the composition of the atmosphere.

Background Information

Spheres of the Earth:

❒ Scientists describe the Earth's system as an interaction of 4 spheres.



- **Atmosphere**: an envelope of many gases arranged in layers around the Earth held in place by gravity.
- **Biosphere**: includes all living organisms found on Earth.
- **Hydrosphere**: includes all the water found on, under, and over the surface of the Earth. Movement of water throughout the 4 spheres of the Earth is called the water cycle.
- **Lithosphere**: is the hard and rigid outer layer of the Earth. This sphere includes the Earth's crust and the uppermost mantle.

❒ Carbon is stored in various forms throughout the 4 spheres.
- Dissolved in water.
- Part of living plants and animals.
- Fossil fuels and buried in the Earth's crust within geologically locked sources.
- Carbon dioxide in the atmosphere.

Understanding the Atmosphere

Earth's atmosphere is composed of different quantities of gases. The atmosphere traps heat and warms our planet's land and the air around it. The trapping of heat by the atmosphere is known as the greenhouse effect.

- Layers: The Earth's atmosphere can be divided into five main layers. The boundaries between each layer are determined by areas where maximum changes in thermal characteristics, chemical composition, movement, and density occur.

Layer Name	Approximate Altitude	Description
Exosphere	690 km to 10,000 km	This is the outermost layer of the earth atmosphere.
Thermosphere	85 km to 690 km	This layer is known as the upper atmosphere. Temperatures in this layer can rise higher than 1,500°C (2,730 °F). The temperatures go up as you increase in altitude due to the Sun's energy.
Mesosphere	50 km to 85 km (53 miles)	Temperature decreases with height in the mesosphere. The temperature minimum that marks the top of the mesosphere, is the coldest place on Earth and has an average temperature around −85 °C (-121.0°F). In this layer water vapor freezes and forms ice clouds.
Stratosphere	Begins between 8-20 km and extends to 50 km (31 miles).	In this layer temperature increases with height. The pressure here is approximately 1/1000th less than the air pressure at sea level. • NOTE: The Ozone layer is mainly located in the upper layer of the stratosphere from about 15–35 km (9.3–22 mi; 49,000–110,000 ft), though the thickness varies seasonally and geographically. About 90% of the ozone in our atmosphere is contained in the stratosphere. The ozone layer absorbs and scatters solar ultraviolet radiation.
Troposphere	Earth's surface to 8-14 km high (5-9 miles)	This is the layer closest to the Earth's surface. This part of the atmosphere is most dense. In this layer as altitude increases, temperature decreases. Almost all weather originates and occurs within this layer. The top of Mount Everest is within this layer.
Earth		

❐ Composition:

The Earth's atmosphere is primarily composed of 78% nitrogen (N_2) and 21% oxygen (O_2). These gases make up 99% of the clean air. Most of the remaining 1% is composed of the inert gaseous element, argon (Ar). The remaining gases in the atmosphere are referred to as trace gases. The trace gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. The concentrations of the trace gases are variable based on environmental events and human impacts.

Some trace gases including carbon dioxide, methane, carbon monoxide, ozone, and nitrous oxide play a significant role in controlling the temperature of the Earth's atmosphere and are referred to as **greenhouse gases**. When in balance the **greenhouse gases** are responsible for trapping solar energy in the form of heat. When the balance of trace gases is disrupted naturally (i.e. volcanic eruptions or forest fires) or when humans add pollutants (i.e. chemicals, particulates, or biological matter) into the atmosphere, the amount of heat that is trapped by the atmosphere is increased. In computer-based models, rising concentrations of greenhouse gases produce an increase in the average surface temperature of the Earth over time. Rising temperatures may, in turn, produce changes in precipitation patterns, storm severity, and sea level commonly referred to as "climate change."

In some instances, such as when a volcano erupts, ash particles in the atmosphere can reflect or block the entry of solar energy into our atmosphere and temporarily reduce surface temperatures.

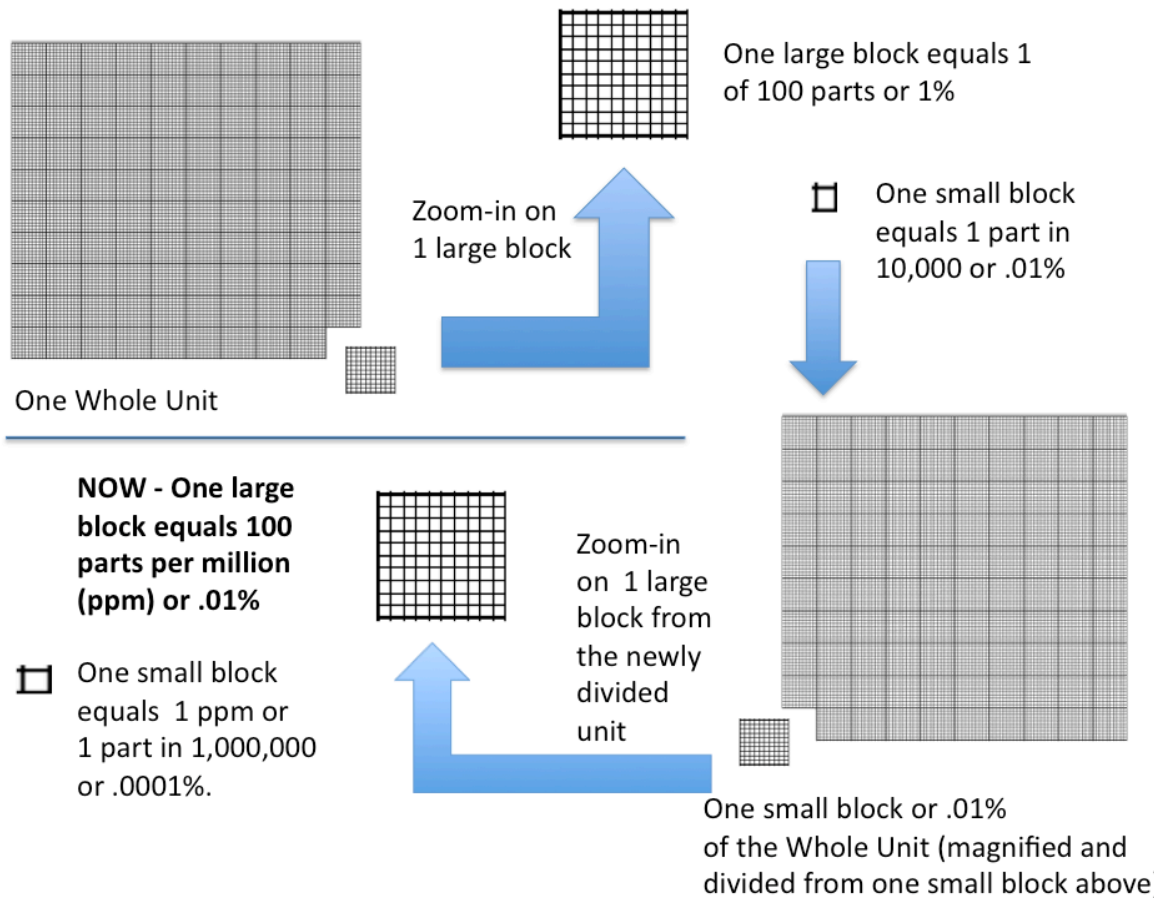
Scientists believe that the composition of our atmosphere is influenced by the presence of life on Earth. Living organisms keep Earth's atmosphere in a dynamic balance. For example, without plants, the Earth would have too little oxygen for humans to survive. Earth's unique stability comes from plants' ability to produce oxygen through photosynthesis and other organisms' ability to re-circulate CO_2.

2010 Atmospheric Composition of Clean Dry Air		
Primary Gases	**Parts by volume**	**Percent (%)**
Nitrogen (N_2)	780,805 ppm	78.08%
Oxygen (O_2)	209,437 ppm	20.95%
Argon (Ar)	9,340 ppm	0.93%
Trace Gases (total)	~400 ppm (varies based on ***CO_2*, CH_4, N_2O, and Ozone levels)**	0.040%
Carbon Dioxide (CO_2)	391 ppm	0.036%
Neon (Ne)	18.2 ppm	Remaining 0.004%
Helium (He)	5.2 ppm	
Methane (CH_4)	1.8 ppm	
Krypton (Kr)	1.1 ppm	
Hydrogen (H_2)	0.5 ppm	
Nitrous Oxide (N_2O)	0.5 ppm	
Carbon Monoxide (CO)	0.1 ppm	
Xenon (Xe)	0.09 ppm	
Ozone	0.07 ppm	
Nitrogen Dioxide (NO_2)	0.03 ppm	
Iodine (I)	0.01 ppm	
Ammonia (NH_3)	*trace*	

Understanding Concentration Measurements

In this activity we use percentages to represent units of gas composition. A percent (%) is equivalent to 1 part out of 100 equal units.**1% = 1 part out of 100**

For smaller concentrations scientists use parts per million (ppm) to represent concentrations of gases or pollutants in the atmosphere. One ppm is equivalent to 1 part out of 1,000,000 if the volume being measured is separated into 1,000,000 equal units.



The concept of parts per million may be difficult for some students to visualize. Here are some examples to use that may help students visualize parts per million:

- The common unit **mg/liter** is equal to ppm concentration.
- Four drops of ink in a 55-gallon barrel of water would produce an "ink concentration" of 1 ppm.
- 1 12-oz can of soda pop in a 30-meter swimming pool
- 1 3-oz chocolate bar on a football field

Atmospheric Composition Activity

- ❒ Ask the students to break into groups of two or have them work individually on their atmospheric composition activity.
- ❒ Tell students that they will be creating a graphic model of the atmosphere composition using the Atmospheric Composition of Clean Dry Air activity sheet.

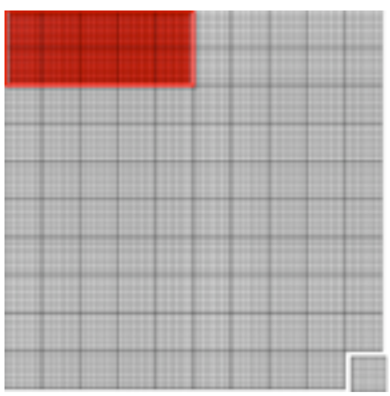
Part 1

1. Page 1 contains a section of graph paper that contains 100 bold grid blocks and 10,000 small blocks. One bold block on the graph paper represents 1% of the volume of the atmospheric composition of clean dry air. Note the **Atmospheric Composition** box on this page. This box contains the percent of the major atmospheric gases nitrogen, oxygen, argon, and the trace gases.
2. Instruct students to select a different color for nitrogen, oxygen, argon, and the trace gases in the **Atmospheric Composition** box. Have students fill in the four empty blocks next to each gas name with a different color to create a key for the atmospheric composition graph.

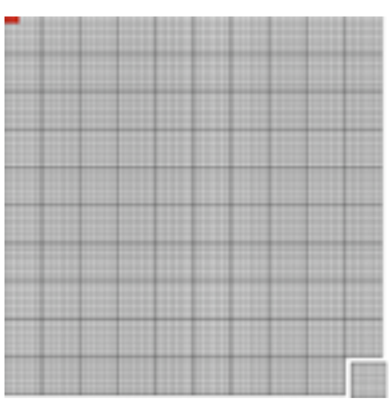
   Note: We recommend using color pencils to complete this activity.

3. Instruct students to color one bold grid block for **each** percentage of the Major Atmospheric Composition gases in the graph paper section. For example, if a gas volume is 1% or 1 part out of 100, you would color 1 large block on the graph paper. A volume of 1% = 10,000 ppm.

   If a gas volume is 10% or 10 parts out of 100, you would color 10 large blocks on the graph paper. A volume of 10% = 100,000 ppm.



4. If a gas volume is less than 1%, one small block is colored for each .01% of a gas volume. For example if a gas' volume is .08%, they would color 8 small blocks on the graph paper. A volume of .08% = 800 ppm.



Implementation Suggestions:
You may wish to display the Earth's Atmospheric Composition graph from the Atmospheric Composition of Clean Dry Air Activity Sheet to the front of the classroom to model how to equate gas volume percentages to the blocks on the graph paper.

Some students may have difficulty with decimal units and may require additional instructional support. For such students, instruct them to estimate the volume of nitrogen and oxygen to the nearest whole percentage. Have them first color nitrogen and oxygen on the graph paper. Have students note that only one bold grid box remains. This represents 1% of the atmosphere. Have students note that the remaining box is composed of 100 smaller boxes.

Prompt students to think about which remaining atmospheric gases would occupy the remaining 1% of the atmosphere.

Next, remind students that each smaller box is equivalent to 1 part in 10,000 or 0.01% of a gas volume. Ask students how many smaller boxes would need to be colored for argon (93 smaller boxes). Instruct students to color argon on their graph paper. Next, ask students how many smaller boxes would need to be colored for trace gases (4 smaller boxes). Instruct students to color trace gases on their graph paper.

Implementation Suggestion: Before students continue to page 2 of the activity sheet, have students note that the amount of trace gases represents only a very small amount of the Earth's atmosphere (.04%).

Part 2

1. Instruct students to look at **page 2** of the activity sheet. The graph on **page 2** is labeled **Argon and Trace Gases**.
2. Page 2 contains another section of graph paper that contains 100 bold grid blocks. One bold grid block on the graph paper now represents.01% or 100 parts per million of the volume of the Atmospheric Composition of Clean Dry Air. Note the **Argon and Trace Gases** box on this page. This box contains the parts per million (ppm) values of argon and the other trace gases.
3. Instruct students to select a different color for carbon dioxide, neon, helium, methane, krypton, hydrogen, and nitrous oxide in the **Argon and Trace Gases** box. They can insert a "\" slash mark for the box next to argon. Have students fill in the empty blocks next to each gas name with a different color. This will serve as a color key for the trace gases that have volumes large enough to depict on the graphical representation.

   Important Note: The students will not select individual colors for carbon monoxide (0.1 ppm), ozone (0.07 ppm), and nitrogen dioxide (0.03 ppm); these concentrations are too small to accurately depict on this graph, they have concentrations in the parts per billion. These are bulleted (•) in the **Argon and Trace Gases** box.

4. Emphasize that the units represented by the blocks on this page have now changed from percentage (parts per hundred) to parts per million. Each square now represents an even smaller portion of the area measured. One large block is 100 parts in one million or 100 ppm or .01%. Each small block is now 1 part in one million or 1 ppm or .0001%.
5. Instruct students to color one bold grid block for **each** 100 ppm of the trace gases on the graph paper. For example, if a gas volume is 100 ppm, they would color 1 bold grid block on the graph paper.
6. For values less than 100 ppm, students should color in the designated number of the smallest squares on the graph paper.

   Note: Two of the trace gases - hydrogen (0.5 ppm) and nitrous oxide (0.5 ppm) - make up 1.0 ppm of Earth's atmosphere. These concentrations are equivalent to one of the smallest squares on the Argon and Trace Gases graph.

Implementation Suggestions:
You may wish to display the Argon and Trace Gases graph from the Atmospheric Composition of Clean Dry Air Activity Sheet to the front of the classroom to model how to equate gas volume in parts per million to the blocks on the graph paper.

For students who have difficulty with using decimal numbers, you may wish to have students round gas volumes to the nearest whole ppm value for prior to shading in the graph.

7. Instruct students to answer the **Analysis Questions** on their activity sheet.

Concluding the Activity:
Tell students that the trace gases carbon dioxide, methane, carbon monoxide, ozone, and nitrous oxide are referred to as **greenhouse gases**. They are called greenhouse gases because they are involved in the Earth's natural greenhouse effect that keeps the planet habitable (livable) and ~30˚C warmer than it would be without the atmosphere. Discuss with students that the increase of these trace gas concentrations in the atmosphere has led to an increase in the average annual global temperature.

Discuss with students the 3 Analysis Questions on the activity sheet. Emphasize to students that the trace gases make up a very small part of our atmosphere (.04%).