

Layers of the Atmosphere

Strand	Matter
Topic	Investigating the atmosphere and weather
Primary SOL	6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth’s atmosphere. Key concepts include a) air as a mixture of gaseous elements and compounds; c) atmospheric changes with altitude.
Related SOL	6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which c) scale models are used to estimate distance, volume, and quantity; i) models and simulations are designed and used to illustrate and explain phenomena and systems.

Background Information

Earth’s atmosphere is a relatively thin layer of gases that protects the planet and allows life to exist. If Earth were compared to an apple, the atmosphere would be the thickness of the peel. The atmosphere is made up of five layers.

- The *troposphere* is the layer that is closest to Earth’s surface, starting at the surface and rising to between 8 and 14.5 km high. It is the only layer in which life exists and virtually all weather occurs. It contains 99 percent of the water vapor in the atmosphere. Due to Earth’s gravitational pull, most of the air molecules that make up the atmosphere are found in the troposphere; therefore, atmospheric pressure is highest in the troposphere. As altitude increases, atmospheric pressure *decreases* because fewer and fewer molecules are present. Temperature in the troposphere also *decreases* as altitude increases.
- The *stratosphere* starts just above the troposphere and rises to about 50 km above Earth’s surface. The stratosphere is dry and much less dense than the troposphere. The ozone layer, which absorbs and scatters solar ultraviolet radiation, is in this layer. Temperature in the stratosphere generally *increases* as altitude increases due to increasing absorption of ultraviolet radiation. The troposphere and stratosphere together contain 99 percent of the air molecules in the atmosphere.
- The *mesosphere* starts just above the stratosphere and extends to about 85 km above Earth’s surface. Temperature in this layer *decreases* to as low as -93°C as altitude increases. Molecules here are in an excited state as they absorb energy from the sun.
- The *thermosphere* starts just above the mesosphere and extends to around 500 km above Earth’s surface. Temperature in this layer can soar to as high as $1,727^{\circ}\text{C}$ due to solar activity. The thermosphere and the upper mesosphere contain the ionosphere, which is a large number of electrically-charged particles (ions). Chemical reactions occur much more quickly here than on the Earth. Light displays, called *auroras*, occur here.

- The *exosphere* starts at the top of the thermosphere and continues upward until it merges with outer space. In this layer, hydrogen and helium are the main gases present.

Materials

- Chart paper
- Construction paper or large sticky notes
- Resource materials with information pertaining to the layers of the atmosphere
- Copies of the attached handout
- Model-making materials (e.g., colored sand, apples, construction paper, dried beans, graph paper, various concentrations of colored water, clear plastic straws, other items requested by students)

Vocabulary

atmosphere, exosphere, mesosphere, stratosphere, thermosphere, troposphere

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction

1. Conduct a short demonstration to assess students' knowledge about the Earth's atmosphere, to set the stage for student research, and to provide questions to focus inquiry. Begin by drawing a large half circle on the lower part of the board to represent the Earth. Ask students to work in groups to formulate answers to the following questions and/or formulate additional questions about the atmosphere.
 - What do you already know about the atmosphere?
 - How might the atmosphere protect living things and make life possible on Earth?
 - How far out into space do you think the atmosphere extends?
 - Are the characteristics of the atmosphere the same near the surface of the Earth as they are at its higher levels? Why, or why not?
2. Provide time for the groups to share with one another in class discussion. Record student answers, questions, and other information on chart paper. Inform students that they will return to these questions at the conclusion of the activity and modify the information on these sheets based on their research.

Procedure

1. Organize students into groups of five each for a jigsaw activity. Have students in each group count off from 1 to 5, and then have the students arrange themselves into new groups based on these numbers. Explain that the "ones" will investigate the troposphere and become an "expert" group on it, the "twos" will become experts on the stratosphere, the "threes" on the mesosphere, the "fours" on the thermosphere, and the "fives" on the exosphere. In addition, each group will gather information to answer the questions posed during the opening of the activity.
2. Distribute research materials and copies of the attached Layers of the Atmosphere table. Materials should contain descriptions of the atmospheric layers, data on the mixture of gases in the layers, and variations of air pressure and temperature due to altitude.

3. While groups are conducting research, circulate to ask them probing questions to prompt thought and additional exploration and research, to ensure that all students are participating, and to make certain that information being gathered is accurate and complete.
4. Once the expert groups have completed their research on their specific atmosphere layers, have students reform their original groups, each of which now contains an expert on one of the five atmospheric layers. Starting with the troposphere experts, have each expert present his/her information to the other members of the group, who will use the information to complete the table.
5. Once their table is completed, each group should review the questions posed at the beginning of the activity to determine whether further research is needed to fully answer them. Have students post their group's answers to all the questions in order to provide a visual reference for the other students (and a formative assessment for the teacher).

Observations and Conclusions

1. Revisit the sheets of chart paper on which answers to the question were recorded earlier. Hold a class discussion to modify the information on these sheets based on what the students have learned. Make entirely new sheets, if necessary.
2. Have students extend and apply their learning by creating a model of the Earth's atmospheric layers, using some of the materials mentioned under Materials above. The model should be designed to reflect an accurate scale of Earth and the layers of the atmosphere. It is important for students to choose for themselves the materials to use to represent what they have learned about the layers of the atmosphere. All models should be different, but effort should be made to represent each layer to scale.
3. Use the answers to the initial questions, the student models, and answers to the following questions to assess students' understanding of the main ideas of the lesson in a class discussion:
 - What have you learned about the atmosphere?
 - How far out into space does the atmosphere extend?

Assessment

- **Questions**
 - What are the atmospheric layers, and what are the characteristics of these layers?
 - How does the atmosphere protect living things and make life possible on Earth?
- **Journal/Writing Prompts**
 - Explain the differences in pressure and temperature among the layers of Earth's atmosphere.
 - Write a poem about the layers of Earth's atmosphere.
- **Other**
 - Use the answers to the initial questions, the student models, and answers to the following questions to assess students' understanding of the main ideas of the lesson in a class discussion:
 - What have you learned about the atmosphere?
 - How far out into space does the atmosphere extend?

- Give students a table of data about the relative thicknesses (in km) and temperatures (in °C) of the atmospheric layers, and each student create a bar graph from the data.
- Have students draw and label scale models of the layers of Earth’s atmosphere.

Extensions and Connections (for all students)

- As a follow-up, or if reinforcement is needed, have students draw the layers of the atmosphere as a series of six semicircles, starting with Earth at the bottom and making each layer’s thickness proportional to its actual thickness. Have them draw and label key characteristics of each layer. For example, they might draw gases, clouds, and weather in the troposphere; the ozone layer in the stratosphere; shooting stars in the mesosphere; auroras or the ionosphere in the thermosphere; and satellites or the space station in the exosphere. Extend this by having students draw the sun at the top of the page and show what happens to solar radiation that enters the atmosphere.

Strategies for Differentiation

- Have students label a diagram depicting the layers of the Earth’s atmosphere before making their models and then use this diagram as a rough draft or plan for their model.
- Have students make models in their small groups, rather than individually.
- Provide pictures (stickers work well) of objects that can be found in the different layers. Have students affix these pictures to their models.
- Invite a pilot or an expert in the field of aviation to describe the changes in flight conditions that occur as altitude increases.
- For the attached Layers of the Atmosphere table, allow student groups to identify and utilize their own research methods to find descriptions of the atmospheric layers, data on the mixture of gases in the layers, and information about variations of air pressure and temperature due to altitude.

Layers of the Atmosphere

Name: _____ Date: _____ Class: _____

Layer	Mass of Air	Altitude	Air Pressure	Temperature	Description
Troposphere					
Stratosphere					
Mesosphere					
Thermosphere					
Exosphere					
Other Information					

Layers of the Atmosphere Answer Key

Layer	Mass of Air	Altitude	Air Pressure	Temperature	Description
Troposphere	75% of atmosphere	8 to 14.5 km thickness, depending on the season	Highest pressure in the atmosphere, due to gravity: 100 to 1,000 mb	<i>Decreases</i> as altitude increases; Range: 17°C to -52°C	<ul style="list-style-type: none"> • Layer where weather occurs • Densest layer with most gases • Layer where life exists • Contains 99% of the water vapor in atmosphere
Stratosphere	24% of atmosphere	14.5 to 50 km (31 mi.) high	Low pressure: 1 to 100 mb	<i>Increases</i> as altitude increases; Range: -52°C to -3°C, due to absorption of ultraviolet radiation	<ul style="list-style-type: none"> • Contains ozone layer, which absorbs ultraviolet radiation • Dry and less dense than troposphere
Mesosphere	A few molecules	50 to 85 km (53 mi.) high	Low pressure: 0.01 to -1 mb	<i>Decreases</i> as altitude increases; Range: -3°C to -93°C	<ul style="list-style-type: none"> • Layer where shooting stars burn
Thermosphere	Very few molecules	85 to 500 km (372 mi.) high	Very low pressure	-93°C to as high as 1,727°C due to the activity of the sun	<ul style="list-style-type: none"> • Contains ionosphere—large number of electrically charged particles (ions) • Light displays, called auroras, over poles (Northern lights)
Exosphere	Only helium and hydrogen molecules at very low density	500 to 800 km (372 to 500 mi.) high; merges with space	Extremely low pressure; very few molecules	1,100°C to 270°C	<ul style="list-style-type: none"> • Satellites, Hubble telescope, and space station orbit here. • Merges with vacuum of outer space
Other Information					