Teaching Activity: Temperature and Pressure Patterns in the Troposphere

Introduction: The layers of air in the atmosphere are held close to the Earth's surface by the force of gravity, and as a result, push down on the Earth's surface. This "push" is called atmospheric pressure, or *air pressure*. The upper layers of air push down on the lower layers so that the air pressure near the surface is greater than the air pressure further from the surface. The "popping" of your ears when you are flying in an airplane is caused by the changes in air pressure. About 99 percent of the mass of the atmosphere is found below 32 kilometers in altitude. The remaining 1 percent is spread out over the hundreds of kilometers of atmosphere that remain. Therefore, air pressure decreases as elevation increases.

The atmospheric temperature structure can be traced to the emission and absorption of solar radiation. The troposphere is heated from below by infrared radiation from the Earth's surface. Convective processes, involving expansion and absorption, are responsible for the decrease in temperature with altitude. In the troposphere this decrease is recorded at about -50 degrees C at altitudes above 10km from middle latitudes to high latitudes, and to about -80 degrees C at 17km in the tropics. An increase in temperature occurs in the stratosphere and is due to the absorption of downflowing ultraviolet radiation and upflowing infrared radiation from the Earth's surface by stratospheric ozone. This increase reaches a maximum at about 50km after which the amount of ozone decreases sharply and temperatures fall to about -100 degrees C at about 90km. Another region of temperature increase is found higher up in the atmosphere and is the result of the absorption of ultraviolet radiation from the Sun by both molecular oxygen and nitrogen.

Important Terms: Air pressure, temperature, convection, altitude, emission, absorption, mass, radiation, troposphere, stratosphere, infrared radiation, ultraviolet radiation;

Objective:

- To construct a graph which illustrates the temperature and air pressure patterns in the Earth's atmosphere;
- To draw conclusions from those graphs regarding the temperature, pressure and altitude relationship;

Materials: Graph paper, pencil, colored pencils, ruler, **Data Table;**

Procedure:

1. Using a ruler and graph paper, students should construct two grids.
    a. The Y-axes on both grids should be labeled:
        Height Above the Earth's Surface (in meters).
    b. The X-axis on the first grid should be labeled:
        Average Air Temperature (in degrees C)
    c. The X-axis on the second grid should be labeled:
        Average Atmospheric Pressure (in millibars)

2. Students should label from 0 - 10000 by thousands (0, 1000, 2000, etc.,) on the Y-axes.

3. Students should label gradations for the X-axis on the air temperature grid beginning at the far left with -50 and continuing to +20 on the far right.
   Ex: -50, -40, -30,-20,-10, 0,+10,+20

4. Students should label gradations for the X-axis on the pressure grid beginning at the far left with zero and continuing to 1200 on the far right.
   Ex: 0,200,400,600,800,1000,1200

5. Students should then plot the data from the **Data Table** on each grid.
   a. A dot should be placed in the correct location for each piece of data.
   b. All the dots should then be connected with a colored line, using a different color for each graph.

6. Students should then answer the questions in the **Analysis and Comprehension** section.

Data Table: Temperature and Pressure Patterns in Earth's Atmosphere

Height Above Earth's Surface (in meters)	Average Atmospheric Pressure (in millibars)	Average Air Temperature (in °C)
0 (sea level)	1013.2	15.0
500	954.6	11.8
1000	898.8	8.5
1500	845.6	5.2
2000	795.0	2.0
2500	746.9	− 1.2
3000	701.2	− 4.5
3500	657.8	− 7.7
4000	616.6	−11.0
4500	577.5	−14.2
5000	540.5	−17.5
5500	505.4	−20.7
6000	472.2	−24.0
6500	440.8	−27.2
7000	411.0	−30.4
7500	383.0	−33.7
8000	356.5	−36.9
8500	331.5	−40.2
9000	308.0	−43.4
9500	285.8	−46.7
10,000	265.0	−49.9

Student Activity Sheet: Temperature and Pressure Patterns in the Troposphere

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- To draw conclusions from those graphs regarding the temperature, pressure and altitudes relationship;

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      Height above the Earth's Surface (in meters)
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   c. The X-axis on the second grid should be labeled:
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   Ex: -50,-40,-30,-20,-10,0,+10,+20

4. Label gradations for the X-axis on the pressure grid beginning at the far left with 0 and continuing to 1200 on the far right.
   Ex: 0,200,400,600, 800, 1000, 1200

5. Plot the data from the **Data Table** on each grid.
   a. Place a dot in the correct location for each piece of data.
   b. Connect all the dots with a colored line. Use a different color for each graph.

6. Answer the questions in the **Analysis and Comprehension** section.

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Analysis and Comprehension Section:

1. What unit of measurement is used for temperature?

2. What unit of measurement is used for air pressure?

3. Describe the way that temperatures in the atmosphere change with an increase in altitude.

4. Describe the way air pressure changes with an increase in altitude.

5. How do the two patterns relate to each other?

6. Predict what would happen to the average temperature of the Earth's surface if the stratospheric ozone layer were depleted by 90 percent.