How High is Space? Teacher Guide

In this exercise, students will explore the layers of the atmosphere as well as the definition of the beginning of space. Students will build a scale model of the atmosphere and label where common and well know objects such as clouds, airplanes, and the space shuttle can be found.

Time required: About 1 hour, including answering questions at the end of the exercise.

Materials required:

- Copy of the student sheet for each student
- Copy of the atmospheric layers information sheet for each student or small group of students
- Copy of the atmosphere scale model for each student or small groups of students
- Transparent tape for each small group of students
- Colored pencils (optional)
- Books or the Internet for further research on the atmosphere and its layers (optional)

Texas Essential Knowledge and Skills (TEKS) for Science (http://www.tea.state.tx.us/rules/tac/chapter112/index.html):

6.2, 6.4, 6.5, 6.13, 6.14C
7.2, 7.5, 7.8B, 7.14A,
8.2, 8.6, 8.7B, 8.10B
IPC: 2, 5.A;C;D, 6.A;B;G

National Science Education Standards:

CONTENT STANDARD D (5-8):
STRUCTURE OF THE EARTH SYSTEM

The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.

CONTENT STANDARD E (5-8):
UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations.

Name_____ Date _____ Period_____

How High is Space?

Part 1

Procedure

1. Tape the six pages numbered sea level to 790 km. Tape these pages together end-to-end like a banner, using clear tape. When you have completed this step, you will have created a scale model of the atmosphere.

2. Fold the pages accordion-style into a stack.

3. Using the information from your information sheet, draw a line across the chart to indicate the top of each atmospheric layer. Draw an arrow from the bottom to the top of each layer. Label each layer.

How High is it?

In lab groups you will compare the heights of layers of Earth's atmosphere to the top of the mesosphere, which is "**astronaut altitude**," the distance from the Earth at which one officially becomes an astronaut. Although still within the atmosphere the astronaut altitude is considered to be the beginning of "space". Above this altitude, planes cannot fly because there is not enough air to provide the lift necessary to allow planes to operate.

4. Add the things listed in the table below to your scale model of the atmosphere.

Table 1: How high is it?

	Altitude Above Sea Level (km)
Peak of Mt. Everest	9 km
Typical Clouds	1 – 10 km
Airplanes	8.5 –11 km
Highest Clouds*	15 km
Astronaut Altitude	80 km (50 miles)
Space Shuttle	320-390 km
International Space Station	390 km
Lowest CINDI (C/NOFS) altitude	375 km
Average CINDI (C/NOFS) altitude	563 km
Highest CINDI (C/NOFS) altitude	750 km

*Thunderheads can "dent" stratosphere

Part 2

Procedure: Your lab group will now research the characteristics of each layer of the atmosphere. Look for typical temperatures or changes in temperature in layers or layer boundaries, as well as presence and density of gases such as ozone and oxygen.

Questions

1. List, in order from the Earth's surface, the layers of the atmosphere.

2. How many layers are there?

3. Which is the lowest layer? Highest?

4. Which layer is the narrowest? Widest?

5. What layer do we live in?

6. Which layer(s) do commercial airplanes use?

7. What layer do the space shuttle and space station orbit in?

8. Mount Everest is how tall? What layer of the atmosphere would you find its peak?

9. How high are the highest cloud tops on Earth? What types of weather do you think produce these clouds?

10. CINDI/CNOFS is located in what atmospheric layer?

11. Which objects in Table 1 are in space and as well as in the Earth's atmosphere?

Layers of the Atmosphere

Our Atmosphere: is a mixture of gases that surround our planet Earth. The atmosphere contains the gases that we need to breathe. It blankets the planet, holding in heat to keep the planet warm and hospitable for life and absorbing harmful ultraviolet radiation from the Sun.

Mercury and our own moon, as well as many other objects in the solar system do not have enough gravity to keep an atmosphere. Earth does have enough gravitational pull to keep most of the atmosphere from escaping into space.

The Earth's atmosphere is made up of a mixture of gases. The main atmospheric gases are 78 percent nitrogen, 21 percent oxygen, and 1 percent argon. The atmosphere also contains small amounts of water vapor, with concentrations varying with latitude and seasons, and a number of trace gases, including carbon dioxide, methane, carbon monoxide, oxides of nitrogen, and ozone. Scientists defined five atmospheric regions or layers based on properties such as whether the temperature is increasing or decreasing within the layer. **Note:** Temperatures and conditions in the atmosphere vary over the course of years, months, and even days. So, the extent of layers varies with time.

Troposphere (from the 0 to ~12 km)

The lowest layer of the atmosphere is the layer in which we live. Temperature decreases with height in the troposphere. Weather systems and clouds are found in this layer. The bulk (about 85 percent) of the total mass of the atmosphere is found in the troposphere. In this layer, a strong, high-altitude wind called the **jet stream** blows eastward, horizontally in the northern hemisphere. The **jet stream** has a large impact on the weather at the Earth's surfaces. The top of the troposphere (tropopause) can reach temperatures as low as 200 K (-73 °C).

Stratosphere (~12 to ~50 km)

The second layer of the atmosphere is the Stratosphere. Temperature increases with altitude in this layer. The Stratosphere contains about 15 percent of the total mass of the atmosphere, but it contains 90 percent of the ozone in the atmosphere. Ozone is an important trace gas that acts as a shield for the Earth's surface by absorbing harmful ultraviolet radiation from the Sun. At the top of the stratosphere (stratopause), temperature can reach about 300 K.

Mesosphere (~50 to ~80 km)

The temperature decreases again with altitude in the third layer, with the upper part of the mesosphere being the **coldest** region in the atmosphere. Most meteors burn up in the mesosphere due to atmospheric friction. The

temperature at the mesopause, the upper boundary of the mesosphere, is about 180 K (–93 °C).

Thermosphere (~80 to ~750 km)

Temperatures increases and soars to over 2,000 degrees Celsius in the fourth layer of the atmosphere. Air pressure is very low here, about one tenth-millionth of that at Earth's surface. The thermosphere is contained within another layer known as the **ionosphere**.

Exosphere (~750+ km)

Gas molecules begin to escape the atmosphere of the Earth when they reach the exosphere. There is no absolute upper boundary to this layer in which the gas becomes more and more thin with increasing altitude, but most scientists adopt a value of about 2000 km.

Ionosphere (~50 km to around 2,000 km)

The ionosphere is a region in the atmosphere in which enough of the atmospheric gas is *ionized* (ionized atoms or molecules have lost or gained electrons) that free electrons can interfere with radio communications. Radio waves are used by communications satellites and by navigations satellites such as GPS (Global Positioning System). This region has multiple atmospheric layers within it. The Coupled Ion Neutral Detection Investigation (CINDI) will fly on an Air Force Spacecraft called C/NOFS to study weather in the ionosphere (space weather) to help predict when changes in the ionosphere may interfere with radio communications.

90 km

80 km

70 km

60 km

50 km

40 km

30 km

20 km

10 km

Sea Level

190 km

180 km

170 km

160 km

150 km

140 km

130 km

120 km

110 km

100 km

290 km

280 km

270 km

260 km

250 km

240 km

230 km

220 km

210 km

200 km

390 km

380 km

370 km

360 km

350 km

340 km

330 km

320 km

310 km

300 km

490 km

480 km

470 km

460 km

450 km

440 km

430 km

420 km

410 km

400 km

590 km

580 km

570 km

560 km

550 km

540 km

530 km

520 km

510 km

500 km

690 km

680 km

670 km

660 km

650 km

640 km

630 km

620 km

610 km

600 km

790 km

780 km

770 km

760 km

750 km

740 km

730 km

720 km

710 km

700 km