CHAPTER 10

The Atmosphere

INTRODUCTION

The thin outer shell of the earth is called the atmosphere. Because it is made up of gases and is usually transparent, we often forget that the air that surrounds the earth is part of the planet. From space, we can see the lithosphere, the biosphere, and the hydrosphere clearly. All we can see of the atmosphere, however, are the clouds that swirl across the earth's surface and the pollution that hangs over cities.

The atmosphere is essential to life on our planet. Without it, earth would be lifeless. There are several reasons why the atmosphere is necessary for life. It:

- provides oxygen for animals to breathe
- provides the carbon dioxide that is essential for photosynthesis
- helps to stabilize the differences in temperature between tropical and polar regions
- traps solar energy in the form of heat and prevents it from escaping into space
- recirculates water, which is essential for all life, and
- shields life forms from the sun's harmful ultraviolet rays.

FIGURE 10.1 *Cloud Formations in the Atmosphere*

Properties of the Atmosphere

Before we can study the atmosphere, there are several important properties or characteristics we must first understand.

The Atmosphere Is Fluid

Because the atmosphere is made up of gases, it is fluid and flows from one place to another. Winds and other atmospheric movements spread these gases throughout the atmosphere. Manufactured chemicals, such as pesticides and **chlorofluorocarbons**, as well as chemicals created as a result of volcanic eruptions and other natural processes, enter the atmosphere at a particular place and eventually flow around the planet. Many of the synthetic chemicals are unsafe once they enter the atmosphere. Some upset ecosystems and endanger both plant and animal life. Consider the example of DDT, an obsolete pesticide that is not **biodegradable**. While this poisonous chemical has not been used for over twenty years, traces of DDT are still found in the tissues of Antarctic penguins thousands of kilometres away from where DDT was originally emitted into the atmosphere!

Gases in the Atmosphere

The atmosphere is made up of many different gases, but nitrogen (approximately 78 per cent) and oxygen (approximately 21 per cent) are the main components. Nitrogen is an important nutrient used by both plants and animals. Oxygen is essential for life and combines with fuels when they are burned. While small in percentage breakdown, however, the remaining gases are not small in importance. Carbon dioxide (0.03 per cent) is essential for plant development. Water vapour (0-4 per cent) is vital to both plants and animals to transport nutrients through cell membranes. These gases are not evenly distributed, however. Carbon dioxide is often more concentrated over crowded cities where it is emitted by cars and factories in the burning of fossil fuels. Higher levels of water vapour, or humidity, are often found over bodies of water and forests.

GEO-Fact

Sometimes clouds formed in the stratosphere from the dust of major explosions affect weather in the troposphere. Volcanic eruptions, meteor collisions, and even nuclear explosions can send enormous quantities of dust high into the atmosphere where it may remain for years. **Paleontologists** speculate that dinosaurs became extinct 65 million years ago when one or more meteors smashed into the planet. The dust that resulted blocked the sun from providing the light and heat needed for photosynthesis. The earth was plunged into darkness for more than three months. Dinosaurs literally starved to death as the plants they needed to survive died off. In modern times, scientists have speculated that a nuclear winter several years long could result if there was a nuclear war because of the massive stratospheric clouds that would be formed.

Mass and the Atmosphere

Just because air is hard to see does not mean that nothing is there. Like all matter, air occupies space and has mass. This mass of air, or **air pressure**, varies from place to place on the earth's surface and according to elevation. Places that are hot have lower air pressure than places that are cold. As the atmosphere tries to equalize the air pressure, winds blow from areas of high pressure to areas of low pressure. This is the basis for weather and climate. Altitude also affects air pressure. This is because there is less air pressing down from above so the mass of air is less. Air pressure at higher elevations is so low that people have to breathe more to get the oxygen they need.

Layers in the Atmosphere

Figure 10.2 shows the four layers of the atmosphere. They are the troposphere, the stratosphere, the mesosphere, and the thermosphere. Not shown in the diagram is the magnetosphere, the force field that extends far into space. While each layer possesses different characteristics, the most important difference is temperature.

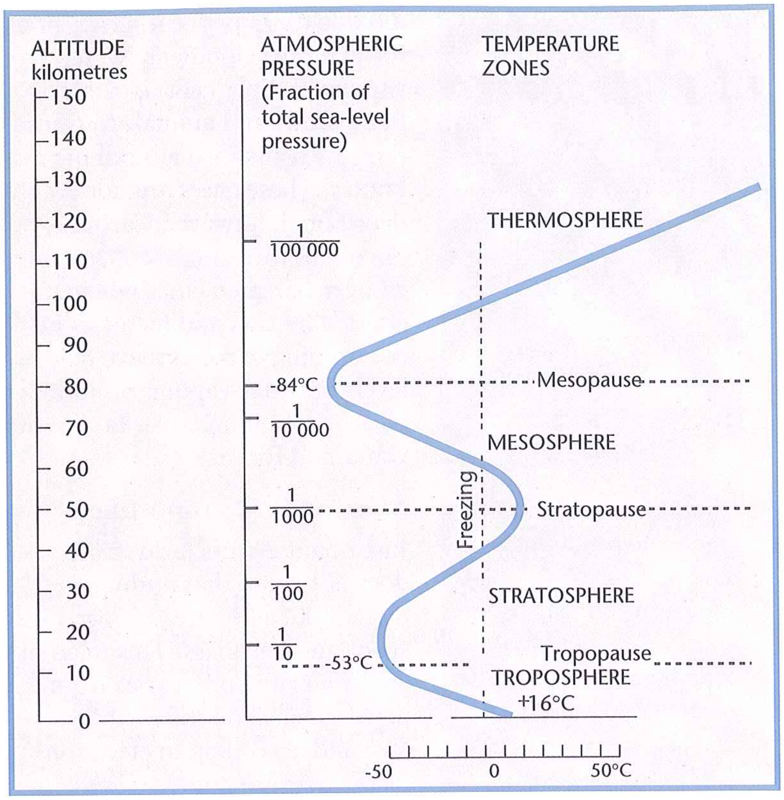

FIGURE 10.2 *Layers of the Atmosphere*

At the top of the troposphere is a transition zone called the **tropopause.** The thickness of the troposphere varies. At the Equator, the troposphere begins at about 16 km above the earth's surface. It gets thinner moving towards the poles, where it is only 9 km thick. The turbulent weather of the troposphere is left behind in the tropopause. The temperature stops falling and stabilizes at about -55°C. Your balloon would have entered a cold, still realm.

Once you pass through the tropopause, you enter the stratosphere. This layer contains the jet stream and the ozone layer. As in the troposphere, the air does not move up and down, but there are considerable horizontal layer-like movements of air. Often storms in the troposphere follow the paths of these rapidly moving upper altitude wind currents created by the coriolis effect.

Spread throughout the stratosphere are molecules of **ozone.** This special form of oxygen absorbs ultraviolet radiation. The energy transfer that occurs as the ozone is broken down increases the temperature in the stratosphere. Heat from the ozone layer radiates up and down, so that the lower layers of the stratosphere are colder than the upper layers where most of the ozone occurs. Thus as your balloon rises through the stratosphere, the temperature gradually increases until it exceeds the freezing point (0°C) 40 km above the earth. The **stratopause** is another transition zone where temperature characteristics change. At this level, the temperature stops increasing as stratospheric ozone thins out with altitude. You are entering the outer atmosphere.

Imagine that you are in a hot-air balloon that is floating up to the top of the atmosphere. You would start your journey directly above the earth's surface in the **troposphere.** This is the most important layer because it is closest to the biosphere. Most life on earth depends on this layer of the atmosphere for survival. The troposphere is influenced most by differences in surface heating and the frictional drag of the planet's rotation. For these reasons, this is the most turbulent layer of the atmosphere. Vertical and horizontal mixing of air is common. Your balloon would be swept this way and that way as it was buffeted by storms and prevailing winds. Another significant characteristic of the troposphere is that the temperature decreases as altitude increases. (See pages 32-33.) By the time the balloon reached the top of this layer, it would be very cold. You would also have passed through 90 per cent of the earth's atmosphere by mass.

After the stratopause, and for the next 30 km, your balloon would pass through the **mesosphere**. Now the temperature begins to drop steadily as you move further away from the earth. Eventually it reaches about -84°C. At this point you enter another transition zone called the **mesopause**. Here the temperature stabilizes, and then starts to increase once again. In the mesopause, the air is so thin that it seems as if you are in outer space.

The next layer, the **thermosphere** (also called the ionosphere), is the thickest one, ranging from 80 to 480 km. The gravitational pull of the earth is so slight that the atmosphere is now quite thin. In the thermosphere, the temperature starts to increase again. The sun's rays break down the molecules of the atmosphere electrically, somewhat like what happens with the ultraviolet rays in the ozone layer. As the **electrons** and **ions** are created in the thermosphere, radiant energy is converted to thermal energy and the temperature rises.

Outside these four layers of atmosphere is the **magnetosphere**. Here the atmosphere gradually gets thinner until there is no more air. It is impossible to tell exactly where the atmosphere ends and outer space begins. Solar dust sometimes gets trapped in the magnetosphere. The rotation of the earth makes the planet behave like a magnet. The charged particles from the sun align themselves with the North and South poles, forming streaks of light in the sky. These Northern Lights, or **aurora borealis**, often light up the dark winter nights in northern Canada.

Like all components of the earth, the atmosphere is a complex part of our existence. Without it, life as we know it could not exist.

Things To Do

1. Explain why the atmosphere is essential to life.
2. Describe the different properties of air.
3. Prepare an organizer comparing the different layers of the atmosphere. Include such criteria as width, air temperature, air movement, and distance from the earth's surface.
4. Explain why the temperature varies with each layer of the atmosphere.

FIGURE 10.3 *The Northern Lights*