In Chapter 10, you focussed on global systems. You learned that Earth is heated unevenly due to its shape. You learned that the tilt of Earth on its axis causes the seasons. You saw that air and ocean currents redistribute the thermal energy around the globe. In this chapter, you will narrow your focus to smaller zones on Earth's surface as indicated by Figure 11.1. You will use the knowledge that you have gained about the factors that influence climates and apply it to smaller regions of Earth. You will also examine the forms of plant and animal life that thrive in various climates.

When you look at Earth from space, you can see apparent movements of air by the shape of the clouds. You can infer weather conditions around the world. If you could look down from space with a very powerful telescope, you might see an elk grazing near the forest in Banff National Park in Alberta.

Describing Climate

If you are going to study the plants and animals that thrive in a variety of climates, you need to know how to describe different climates. You often hear the terms tropical, cool, temperate, dry, or polar used to describe the climate of a region. How can you summarize specific factors that will define a climate?

Temperature is a critical element in defining a climate. In Chapter 10, you learned that the temperature of a region is determined primarily by the amount of thermal energy reaching the ground in the region. In addition, the movements of air and water near the region will carry thermal energy to or from a region. Another important factor that influences climate is altitude. If you have ever hiked or climbed in the mountains, you know that as you climb higher, the temperature drops. On the average, temperature drops about 4.5°C with every kilometre increase in altitude. The reason for the cooling is that solar energy warms the ground, not the air. When a mass of air moves toward a mountain range, it is forced up the mountain. When warm air rises, the height of air above it decreases and the pressure drops. The air expands when the pressure decreases and expansion causes cooling. Cool air at high altitudes affects the plants that grow there (see Figure 11.2).
In addition to temperature, water is one of the most important factors affecting the climate of an area. **Humidity** is the amount of water vapour in the air. Humidity is usually reported as percent humidity — the percent of the maximum amount of water vapour in the air that is possible at that specific temperature. In Chapter 10, you learned about phase changes. You discovered that when water molecules gain enough kinetic energy, they can escape from a liquid and become a gas. Therefore, at higher temperatures, more water molecules have enough kinetic energy to exist as a gas than at lower temperatures. For example, imagine that the humidity is 65 percent on days with temperatures of 30°C and 10°C. The total amount of water vapour in the air will be much greater on the 30°C day than on the 10°C day.

If the humidity is low, organisms can dry out and die. For example, each year many trees in southern Alberta die during the winter when warm, dry chinook winds reduce the percent humidity of the air.

**Temperature and Precipitation Patterns**

When a mass of air cools for any reason, thermal energy is removed from the water vapour as well as the air. Often, the water vapour cannot all remain in the gaseous state at that lower temperature. Water begins to condense and form a liquid. The temperature at which water condenses and begins to fall as rain or snow is called the **dew point** temperature. **Precipitation** is the amount of water that condenses and falls in the form of rain, snow, sleet, and hail. Precipitation is recorded in millimetres of liquid water.

Differences in temperature have an important effect on precipitation patterns. In areas where the solar energy heats the ground to a high temperature, the ground heats the air. Water from the ground, plants, ponds, or lakes, evaporates into the warm air. The air warms, expands, and rises, eventually reaching cooler air above. When the moist air cools, the water vapour condenses and falls as rain. You usually think of rain forests as being near the equator. However, it is possible to have a rain forest in the temperate zone. As you learned in Chapter 10, air typically rises near 60°N. Rising moist air generates frequent rain. Orographic precipitation adds to the moisture on the coast of British Columbia as shown in Figure 11.3.

In Chapter 10, you saw regions of falling air. In these regions, the cool upper air warms as it descends and thus has a greater capacity for water vapour. As a result, the percent humidity decreases. Hot deserts are typically found in tropical zones where air is descending. Two examples of such deserts are shown in Figure 11.4.
Climatographs

Scientists have developed a tool called a climatograph to compare the climates of different regions. A **climatograph** is a graphical representation of climate data for a specific region and time period. The climate data include a region's average monthly temperature and the total monthly precipitation. Both the average monthly temperature and the total monthly precipitation are usually averaged over 30 years. Temperature is recorded in degrees Celsius (°C) and precipitation is in millimetres of rain (mm). Snowfall is converted to rain. Usually 10 mm of snow is equivalent to 1 mm of rain. Figure 11.5 shows data and a climatograph for Calgary, Alberta.

Some features of the climatographs you will find in this unit include:

- The horizontal axis is for the months. These graphs normally begin in January and end in December.
- There are two vertical axes; the left one is for precipitation and the right one is for temperature.
- “Precipitation (mm)” is the total precipitation for the month and “Temperature (°C)” is the average daily temperature averaged for each month.
- The bar graph displays the average monthly rainfall. Use the left hand scale to determine the amount of precipitation (mm) that falls in the region each month.
- The line graph displays the average monthly temperature in the area. Use the right hand scale to determine the average temperature (°C) for this region each month.

You will make a climatograph in the next investigation.

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**Calgary, AB 51°N (1961–1990)**

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (mm)</th>
<th>Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>12</td>
<td>-10</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>-6</td>
</tr>
<tr>
<td>M</td>
<td>15</td>
<td>-3</td>
</tr>
<tr>
<td>A</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>M</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>J</td>
<td>77</td>
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<td>A</td>
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<td>S</td>
<td>48</td>
<td>11</td>
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<td>O</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>N</td>
<td>12</td>
<td>-3</td>
</tr>
<tr>
<td>D</td>
<td>13</td>
<td>-8</td>
</tr>
</tbody>
</table>

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**Figure 11.5** Calgary climate data and example climatograph
How to Make a Climatograph

Think About It

How do you make a climatograph from climate data?

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (mm)</th>
<th>Temp ('C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>23</td>
<td>-14</td>
</tr>
<tr>
<td>F</td>
<td>18</td>
<td>-10</td>
</tr>
<tr>
<td>M</td>
<td>18</td>
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<td>A</td>
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<td>S</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>O</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>-5</td>
</tr>
<tr>
<td>D</td>
<td>22</td>
<td>-12</td>
</tr>
</tbody>
</table>

4. Enter the data for each month’s average precipitation as a bar graph. Use a blue pencil to shade in the bar graph.

5. Enter the data for each month’s average temperature in the middle of the space allocated for that month. Use a red pencil to draw a curve between the points.

6. Add a title to your climatograph.

Materials

- graph paper
- ruler
- coloured pencils (red, blue, green, black)

Apparatus

What to Do

1. On graph paper, mark 12 intervals on the horizontal axis. Label each interval with the first letter of the month starting with “J” for January. Label the axis, “Month.”

2. On the left vertical axis for precipitation, mark nine intervals beginning at 0 and extending to 180. Each interval has a value of 20. Label this axis “Precipitation (mm).”

3. Draw a second vertical axis for temperature on the right. On this axis mark seven intervals beginning with -35° and extending to +25°. Each interval has a value of 10°. Label this axis “Temperature (°C).”

Analyze

1. For the climatograph you made:
   (a) Which month has the lowest average temperature?
   (b) What was the average temperature for the month of May?
   (c) Which month was the driest?
   (d) Which month was the wettest?

2. Assume that a growing season must have average temperatures above +5°C. For how many months of the year can plants grow in this location?

3. With a partner or in a group, try to make a reasonable inference about which Alberta city is represented by this climatograph.

Extend Your Skills

4. Suppose each month’s average temperature increased by 4°C. How long would the growing season be under these conditions?

Skill

FOCUS

Review Skill Focus 7 for using a computer to make graphs.
Organization of the Biosphere

Although the biosphere is a relatively thin layer on Earth's surface, it is much too large to study as a whole. Scientists usually break it down into more manageable components. Climatographs are an excellent tool to help define smaller components of the biosphere that have similar climates. Scientists can study the plant and animal life in these regions called biomes. A biome can be defined as a major geographic region with similar environmental conditions and life forms. It is the largest geographical biotic unit.

You have probably heard the terms habitat and ecosystem. You might wonder how they are related to a biome. One way to visualize the relationship is to use an inverted (upside down) triangle, as shown in Figure 11.6. The top of the triangle represents a biome. The next level down represents an ecosystem. An ecosystem is usually described as the community of living organisms that interact with each other and with the non-living, physical environment. Earthworms that live in the soil provide an example of these interactions. They feed on dead plants and release nutrients such as carbon and nitrogen into the soil, thus providing nutrients that help other plants grow. The worms also dig tunnels through the soil which allow air and water to reach the roots of plants.

At the bottom of the inverted triangle is an organism's habitat. The habitat is most commonly defined as the place where an organism lives, or the place where the organism is usually found. The habitat of an organism could be the physical environment, such as a bird's nest at the edge of a pond. The habitat could be another living thing. For example, the habitat for a certain species of mite is the feathers of a bird.

Types of Biomes

Freshwater and ocean (aquatic) biomes dominate the biosphere. However, you will now focus on terrestrial biomes. The vegetation in a biome is determined by the climate of that region. For example, a warm, arid climate in the rain shadow of a mountain range can result in the development of a desert with characteristic plants. A warm, moist climate would encourage the growth of a forest and the likelihood of forest dwelling plants. All terrestrial biomes have certain characteristic microorganisms, fungi, and animals that have adapted to their particular environment.

Classifying Terrestrial Biomes

Some scientists recognize 10 distinct terrestrial biomes. Others divide the biosphere into 16 or more categories. In this unit you will use a classification system based on six biomes (see Figure 11.7 on the next page). Grassland and desert are familiar terms. Sometimes you hear people speak of “the frozen tundra,” which tells you something about that biome. Taiga is the home of coniferous evergreen forests that grow where there is a moderate amount of rain and cold winter temperatures. Deciduous forests contain trees that lose their leaves in the fall and grow new ones each spring. Tropical rain forests can be found in regions near the equator, where the temperature is warm and there is a great deal of rain.
Did You Know?
The term “aquatic biome” is used to describe oceans and fresh water. Over 75 percent of the biosphere is made up of aquatic biomes. Marine algae are a major source of oxygen for the world. These algae also consume huge amounts of CO₂ from the atmosphere. Aquatic biomes include rivers, lakes, estuaries, intertidal zones, coral reefs, oceanic pelagic zones, and abyssal zones.

Examine the map in Figure 11.7. As you can see, a single biome can be widely scattered around the planet. For example, the northern boreal forest forms a circumpolar band across Canada, through northern Europe and Asia. Why do many widely separated regions of the world have similar biomes? Although there are countless interactions in the biosphere, the simple answer is climate. Patterns of climate result in similar biome distributions over the Earth’s surface.

Figure 11.7 This map shows one system of classifying the biomes of the world. Which biomes are found in Canada? Identify the biome where you live. At what other location in the world is the same biome found?

Figure 11.8 Biomes in different locations might contain different species. For example, in the coniferous (cone bearing) forests of North America, red spruce is common in the east. Black spruce and white spruce are abundant in more western regions. Even though the plants are different species, the dominant vegetation is the coniferous tree.

Figure 11.9 Deserts are found on most continents. Cactus plants, similar to the one in this photograph, are only found in North and South American deserts. However, small trees or shrubs are found in many deserts. This stunted vegetation usually has very small leaves that are often shed during the hottest part of the year. They also have extensive root systems that often penetrate as far as 50 m into the ground in search of water.
Section 11.1 Summary

In this section, you discovered that scientists classify regions of the globe according to climate. A climatograph is a good tool to help describe the climate of a region. When scientists study climatographs for the terrestrial regions of the globe, they sometimes group them into six groups called biomes. The climate in a biome determines the type of plants that grow there. Animals that are adapted to thrive in that climate and on those plants live in the biome. Biomes can be subdivided into ecosystems. Many habitats coexist in an ecosystem.

Check Your Understanding

1. What are the two main factors that determine the climate of a region?
2. (a) What is a climatograph?
   (b) What types of data are included on a climatograph?
3. How does altitude affect temperature?
4. How might humidity influence the type of organisms found in a region?
5. How do you construct a climatograph?
6. What is a biome?
7. What is the relationship among biomes, habitats, and ecosystems?
8. There are a number of systems used to classify biomes. List the six biomes identified in this chapter.
9. Thinking Critically Examine Figure 11.4. How are the two deserts alike? How do they differ? What factors might account for their differences?