It started as a small disturbance in the Atlantic Ocean, east of the Caribbean islands in early July. But as is often the case in the summer hurricane season, the disturbance soon became a tropical storm, and then, after its winds were clocked at greater than 125 kilometers per hour (74 mph), it was designated Bertha, the second full-blown hurricane of the 1996 season. Fed by warm tropical waters, the hurricane advanced westward (Figure 4.1).

In the tourist town of Charlotte Amalie, on the island of St. Thomas in the Virgin Islands, cleanup, especially the replacement of roofs blown off by Hurricane Marilyn in 1995, was proceeding slowly. The blue tarps used to protect the houses began to dot the sky like so many flying carpets as Bertha began to demonstrate its fury.

Bertha did not stop after creating havoc in the Virgin Islands, Puerto Rico, and the Bahamas. High winds downed trees, and damaged houses. Wind-driven high water flooded coastal regions; roads were washed out. Six people were killed. The hurricane plowed into coastal North Carolina at the height of the summer vacation season. A million people left the low-lying coastal areas from Florida to Virginia for fear that waves, winds, and rising water would put their lives in jeopardy. Fortunately, early warning bulletins from Miami's Hurricane Warning Center gave people time to escape. Still, Hurricane Bertha caused great disruption and devastation in coastal North Carolina communities hit by 169-kilometer-per-hour (105-mph) winds, heavy rain, and seas that rose 2.4 meters (8 ft) above high tide. Before it spun itself out, coastal areas from North Carolina to Nova Scotia, Canada, experienced beach erosion and heavy rains.

■ ■ ■

The power of hurricanes is concentrated in a narrow path. Whether such meteorological events occur in Asia or North America, they do great damage. The lives of all in the paths of these storms are affected. Tropical storms are one extreme type of weather phenomenon. Most people are "weather watchers"—they watch television forecasts with great interest and plan their lives around weather events. In this chapter, we review the subsection of physical geography concerned with weather and climate. It deals with normal, patterned phenomena from which such extreme weather events as Hurricane Bertha occasionally emerge.

Figure 4.1 **Path of the July 1996 Hurricane Bertha.** Hardest hit were the Bahamas and the North Carolina coast, but a great deal of rain and wind affected areas as far north as Maine. Wind speeds are shown in parentheses, in miles per hour.

A weather forecaster describes current conditions for a limited region, such as a metropolitan area, and predicts future weather conditions. If the elements that make up the **weather,** like temperature, wind, and precipitation, are recorded at specified moments in time, such as every hour, an inventory of weather conditions can be developed. By finding trends in data that have been gathered over an extended period of time, we can speak about typical conditions. These characteristic circumstances describe the **climate** of a region. Weather is a moment's view of the lower atmosphere, while climate is a description of typical weather conditions in an area or at a place over a period of time. Geographers analyze the differences in weather and climate from place to place in order to understand how climatic elements affect human occupance of the earth.

In geography, we are particularly interested in the physical environment that surrounds us. That is why the **troposphere,** the lowest layer of the earth's atmosphere, attracts our attention. This layer, extending about 10 kilometers (6 mi) above the ground, contains virtually all of the air, clouds, and precipitation of the earth.

In this chapter, we try to answer the questions usually raised regarding characteristics of the lower atmosphere. By discussing these answers from the viewpoint of averages or average variations, we attempt to give a view of the earth's climatic differences, a view held to be very important for understanding the way people use the land. Climate is a key to understanding, in a broad way, the distribution of world population. People have great difficulty living in areas that are, on average, very cold, very hot, very dry, or very wet. They are also negatively affected by huge storms or flooding. In this chapter, we first discuss the elements that constitute weather conditions, and then describe the various climates of the earth.

Air Temperature

Perhaps the most fundamental question about weather is: Why do temperatures vary from place to place? The answer to this question requires the discussion of a number of concepts to help focus on the way heat accumulates on the earth's surface.

Energy from the sun, called *solar energy,* is transformed into heat, primarily at the earth's surface and secondarily in the atmosphere. Not every part of the earth or its overlying atmosphere receives the same amount of solar energy. At any given place, the amount of incoming solar radiation, or **insolation,** available depends on the intensity and duration of radiation from the sun. These are determined by both the angle at which the sun's rays strike the earth and the number of daylight hours. These two fundamental factors, plus the following five modifying variables, determine the temperature at any given location:

1. the amount of water vapor in the air;
2. the degree of cloud cover (or cover in general);
3. the nature of the surface of the earth (land or water);
4. the elevation above sea level;
5. the degree and direction of air movement.

Let us look at these factors briefly.

Earth Inclination

The axis of the earth, that is, the imaginary line connecting the North Pole to the South Pole, always remains in the same position. It is tilted about 23.5° away from the perpendicular (Figure 4.2). Every 24 hours the earth rotates once on that axis, as shown in Figure 4.3. While rotating, the earth is slowly revolving around the sun in a nearly circular annual orbit (Figure 4.4). If the earth were not tilted from the perpendicular, the solar energy received *at a given latitude* would not vary during the course of the year. The rays of the sun would directly strike the equator, and as distance away from the equator became greater, rays would strike the earth at ever-increasing angles, therefore diminishing

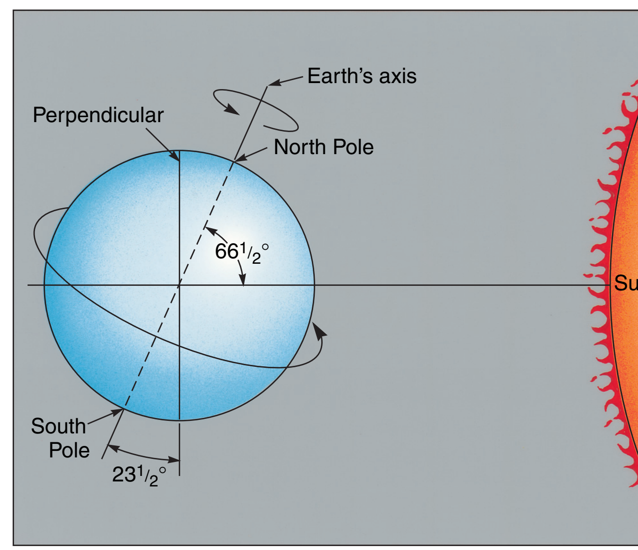

Figure 4.2 The earth's position relative to the sun. The earth is in its summer position in the Northern Hemisphere (winter in the Southern Hemisphere).

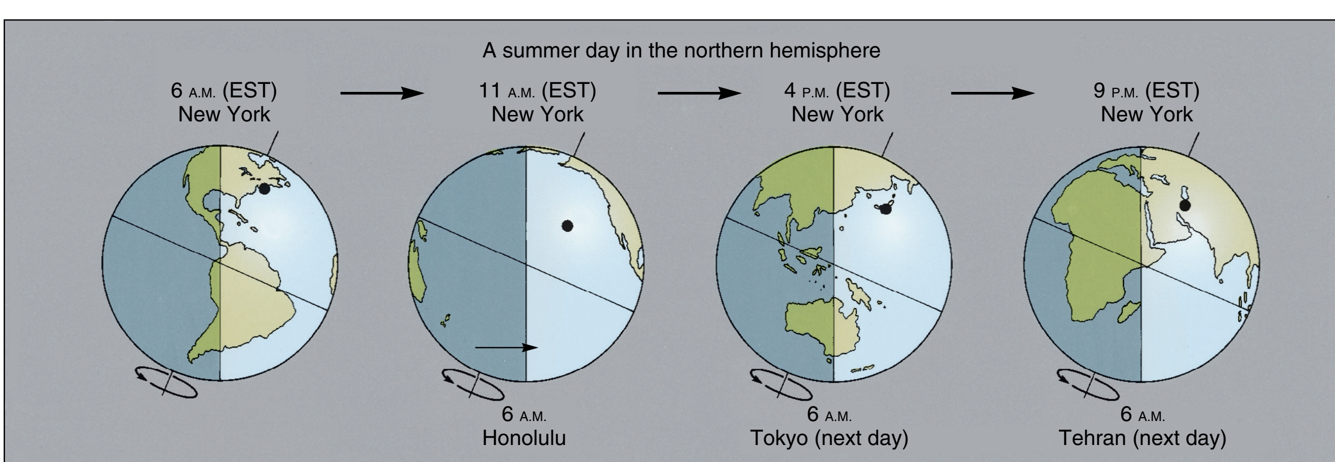

Figure 4.3 The process of the 24-hour rotation of the earth on its axis.