Maps

The geographer's greatest ally is the map. Maps can present enormous amounts of information very effectively, and can be used to establish theories and solve problems. Furthermore, maps often are fascinating, revealing things no other medium can. It has been said that if a picture is worth a thousand words, then a map is worth a million.

Maps can be fascinating, but they often do not get the attention they deserve. You may spend 20 minutes carefully reading a page of text, but how often have you spent 20 minutes with a page-size map, studying what it reveals? No caption and no paragraph of text can begin to summarize what a map may show; it is up to the reader to make the best use of it. For example, in the chapters on population issues we study several maps that depict the human condition by country, in terms of birth and death rates, infant mortality, calorie intake, life expectancy, and so on. In the text, we can refer only to highlights (and low points) on those maps. But make a point of looking beyond the main issue to get a sense of the global distributions these maps represent. It is part of an intangible but important process: to enhance your mental map of this world.

While on the topic of maps, we should remind ourselves that a map—any map—is an incomplete representation of reality. In the first place, the map is smaller than the real world it represents. Second, it must depict the curved surface of our world on a flat plane, for example, a page of this book. And third, it must contain symbols to convey the information that must be transmitted to the reader. These are the three fundamental properties of all maps: scale, projection, and symbols.

Understanding these basics helps us interpret maps while avoiding their pitfalls. Some maps look so convincing that we may not question them as we would a paragraph of text. Yet maps, by their very nature, to some extent distort reality. Most of the time, such distortion is necessary and does not invalidate the map's message. But some maps are drawn deliberately to mislead. Propaganda maps, for example, may exaggerate or distort reality to promote political aims. We should be alert to cartographic mistakes when we read maps. The proper use of scale, projection, and symbolization ensures that a map is as accurate as it can be made.

MAP SCALE

The *scale* of a map reveals how much the real world has been reduced to fit on the page or screen on which it appears. It is the ratio between an actual distance on the ground and the length given to that distance on the map, using the same units of measurement. This ratio is often represented as a fraction (e.g., 1;10,000 or 1/10,000). This means that one unit on the map represents 10,000 such units in the real world. If the unit is 1 inch, then an inch on the map represents 10,000 inches on the ground, or slightly more than 833 feet. (The metric system certainly makes things easier. One centimeter on the map would actually represent 10,000 cm or 100 meters.) Such a scale would be useful when mapping a city's downtown area, but it would be much too large for the map of an entire state. As the real-world area we want to map gets larger, we must make our map scale smaller. As small as the fraction 1/10,000 seems, it still is 10 times as large as 1/100,000, and 100 times as large as 1/1,000,000. If the world maps in this book had fractional scales, they would be even smaller. A large-scale map can contain much more detail and be far more representative of the real world than a small-scale map. Look at it this way: when we devote almost a full page of this book to a map of a major city (Fig. A.1), we are able to represent the layout of that city in considerable detail. But if the entire continental realm in which that city is located must be represented on a single page, the city becomes just a large dot on that small-scale map, and the detail is lost in favor of larger-area coverage (Fig. A.2). So the selection of scale depends on the objective of the map.
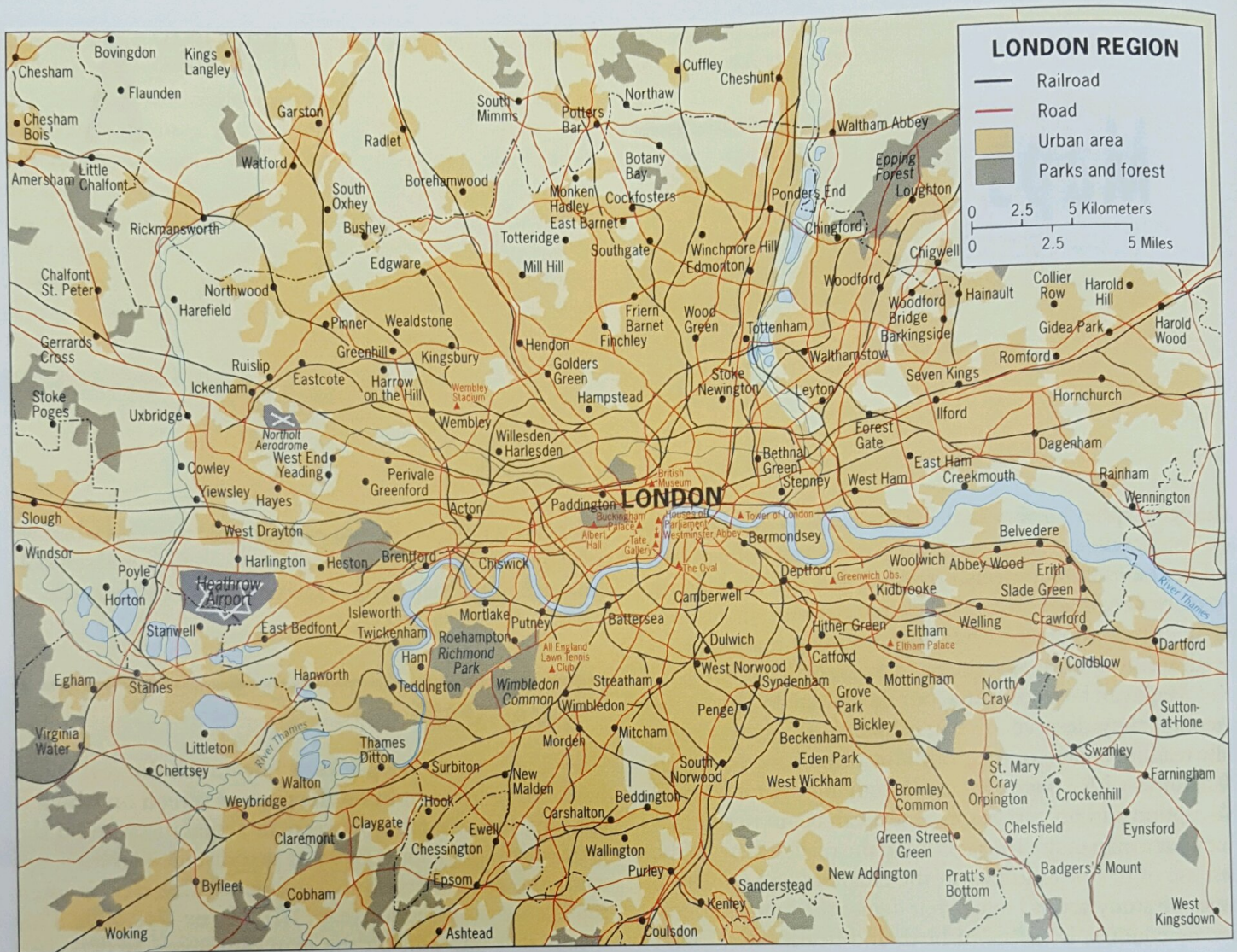
Figure A.1
The layout of a major city can be shown in considerable detail at this **large scale**.

But when you examine the maps in this book, you will note that most, if not all, of them have scales that are not given as ratios or fractions, but in graphic form. This method of representing map scale is convenient from several viewpoints. Using the edge of a piece of paper and marking the scale bar's length, the map reader can quickly—without calculation—determine approximate distances. And if a map is enlarged or reduced in reproduction, the scale bar is enlarged or reduced with it and remains accurate. That, of course, is not true of a ratio or fractional scale. Graphic scales, therefore, are preferred in this book.

MAP PROJECTIONS

For centuries cartographers have faced the challenge of map projection—the representation of the spherical Earth, or part of it, on a flat surface. To get the job done, there had to be a frame of reference on the globe itself, a grid system that could be transferred to the flat page. Any modern globe shows that system: a set of horizontal lines, usually at 10-degree intervals north and south from the equator, called *parallels*, and another set of vertical lines, converging on the poles, often shown at 15-degree intervals and called *meridians* (see box, "Numbering the Grid Lines"). On the spherical globe, parallels and meridians intersect at right angles (Fig. A.3).

But what happens when these lines of latitude (parallels) and longitude (meridians) are drawn to intersect at right angles on a flat piece of paper? At the equator, the representation of the real world is relatively accurate. But go toward the poles, and distortion grows with every degree until, in the northern and southern higher latitudes, the continents appear not only stretched out but also misshaped (Fig. A.4). Because the meridians cannot be made to converge in the polar areas, this pro-

THE BRITISH ISLES

Legend	
Railroad	
Road	
Canal	
Gas pipeline	
Oil pipeline	
◆ Gasfield	
⚲ Oilfield	
▨ Coalfield	

POPULATION

- Under 50,000
- 50,000–250,000
- 250,000–1,000,000
- 1,000,000–5,000,000
- Over 5,000,000

National capitals are underlined

- - - Maritime Boundaries

▨ Area of Catholic majority in N. Ireland

▨ Area with a majority of Welsh speakers

0	50	100	150	200	250 Kilometers
0	25	50	75	100	125	150 Miles

Figure A.2
Smaller scale allows display of larger area, but with less local detail.

jection makes Antarctica look like a giant, globe-girdling landmass.

Looking at this representation of the world, you might believe that it could serve no useful purpose. But in fact, the *Mercator* projection, invented in 1569 by Gerardus Mercator, a Flemish cartographer, had (and has) a very particular function. Because parallels and meridians cross (as they do on the spherical globe's grid) at right angles, direction is true everywhere on this map. Thus the Mercator projection enabled navigators to maintain an accurate course at sea simply by adhering to compass directions and plotting straight lines. It is used for that purpose to this day.

The spatial distortion of the Mercator projection serves to remind us that scale and projection are

Numbering the Grid Lines

When cartographers girdled the globe with their imaginary grid lines, they had to identify each line by number, that is, by degree. For the (horizontal) latitude lines, that was easy: the equator, which bisects the Earth midway between the poles, was designated as 0° (zero degree) Latitude, and all parallels north and south of the equator were designated by their angular position (Fig. A.3). The parallel midway between the equator and the pole, thus, is 45° North Latitude in the Northern Hemisphere and 45° South Latitude in the Southern Hemisphere.

But the (vertical) longitude lines presented no such easy solution. Among the parallels, the equator is the only one to divide the Earth into equal halves, but all meridians do this. During the second half of the nineteenth century, maps with conflicting numbers multiplied, and it was clear that a solution was needed. The most powerful country at the time was Britain, and in 1884, international agreement was reached whereby the meridian drawn through the Royal Observatory in Greenwich, England, would be the prime meridian, 0° (zero degree) Longitude. All meridians east and west of the prime meridian could now be designated by number, from 0° to 180° East and West Longitude.

interconnected. What scale fraction or graphic scale bar could be used here? A scale that would be accurate at the equator on a Mercator map would be quite inaccurate at higher latitudes. So the distortion that is an inevitable byproduct of any map projection also affects map scales.

One might imagine that the spatial (areal) distortion of the Mercator projection is so obvious that no one would use it to represent the world's countries. But in fact, many popular atlas maps (Mercator also introduced the term *atlas* to describe a collection of maps) and wall maps still use a Mercator for such purposes. The National Geographic Society published its world maps on a Mercator projection until 1988, when it finally abandoned the practice in favor of a projection developed by the American cartographer Arthur Robinson (Fig. A.5). During the news conference at which the change was announced, a questioner rose to pursue a point: Why had the Society waited so long to make this change? Was it because the distortion inherent in the Mercator projection made American and European middle-latitude countries large, compared to tropical countries in Africa and elsewhere? Although that was not the goal of the National Geographic Society, the questioner clearly understood the misleading subtleties inherent even in so apparently neutral a device as a map projection.

The Mercator projection is one of a group of projections called *cylindrical* projections. Imagine the globe's lines of latitude and longitude represented by a wire grid, at the center of which we place a bright light. Wrap a piece of photographic paper around the wire grid, extending it well beyond the north and south poles, flash the bulb, and the photographic image will be that of a Mercator projection (Fig. A.6). We could do the same after placing a cone-shaped of paper over each hemisphere, touching the grid, say, at the 40th parallel north and south; the result would be a *conic* projection (Fig. A.7). If we wanted a map of North America or Europe, a form of conic projection would be appropriate. Now the meridians do approach each other toward the poles (unlike the Mercator projection), and there is much less shape and size distortion. And if we needed a map of Arctic and Antarctic regions, we would place the photographic paper as a flat sheet against the North and South Poles. Now the photographic image would show a set of diverging lines, as the meridians do from each pole, and the parallels would appear as circles (Fig. A.8). Such a *planar* projection is a good choice for a map of the Arctic Ocean or the Antarctic continent.

Projections are chosen for various purposes. Just as the Mercator is appropriate for navigation because direction is true, other projections are designed to preserve areal size, keep distances real, or maintain the outlines (shapes) of

Figure A.3
Numbering of **grid lines**.
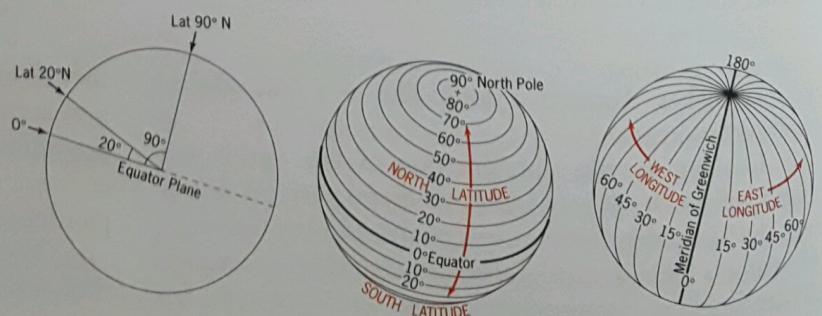
Figure A.4
Mercator's Projection greatly exaggerates the size and shape of higher-latitude landmasses, but direction is true everywhere on this map.

landmasses and countries. Projections can be manipulated for many needs. In this book, we examine global distributions of various phenomena. The world map that forms the base for these displays is one that is designed to give prominence to land areas at the expense of the oceans. This is achieved by "interrupting" the projection where loss of territory (in this case water area) is not problematic.

When a map is planned, therefore, the choice of projection is an important part of the process. An inappropriate selection may weaken the effectiveness of a map and may lead to erroneous interpretations. Of course, the problem diminishes when the area to be mapped is smaller and the scale larger. We may consider various alternatives when it comes to a map of all of North America, but a map

of a single State presents far fewer potential problems of distortion. And for a city map—even of a large city such as Chicago—the projection problem virtually disappears.

The old problem of how to represent the round Earth on a flat surface has been attacked for centuries, and there is no single best solution. What has been learned in the process, however, will be useful in fields of endeavor other than Earthly geography. As the age of planetary exploration dawns, and our space probes send back images of the surfaces of the Moon, Mars, Jupiter, and other components of our solar system, we will have to agree once again on grids, equators, and prime meridians. What has been learned in our efforts to map and represent the Earth will be useful in depicting the universe beyond.

The Robinson projection substantially reduces the exaggerated size of polar landmasses. It better approximates shape, but it lacks the directional utility of the mercator projection.

SYMBOLS ON MAPS

The third fundamental property of a map is its symbolization. Maps represent the real world, and this can be done only through the use of symbols. Anyone who has used an atlas map is familiar with some of these symbols: prominent dots (perhaps black or red) for cities; a large dot with a circle around it, or a star, for capitals; red lines for roads (double lines for four-lane highways), black lines for railroads; and patterns or colors for areas of water, forest, or farmland. Notice that these symbols respectively represent points, lines, and areas on the ground. For our purposes, we need not go further into map symbolization, which can be-
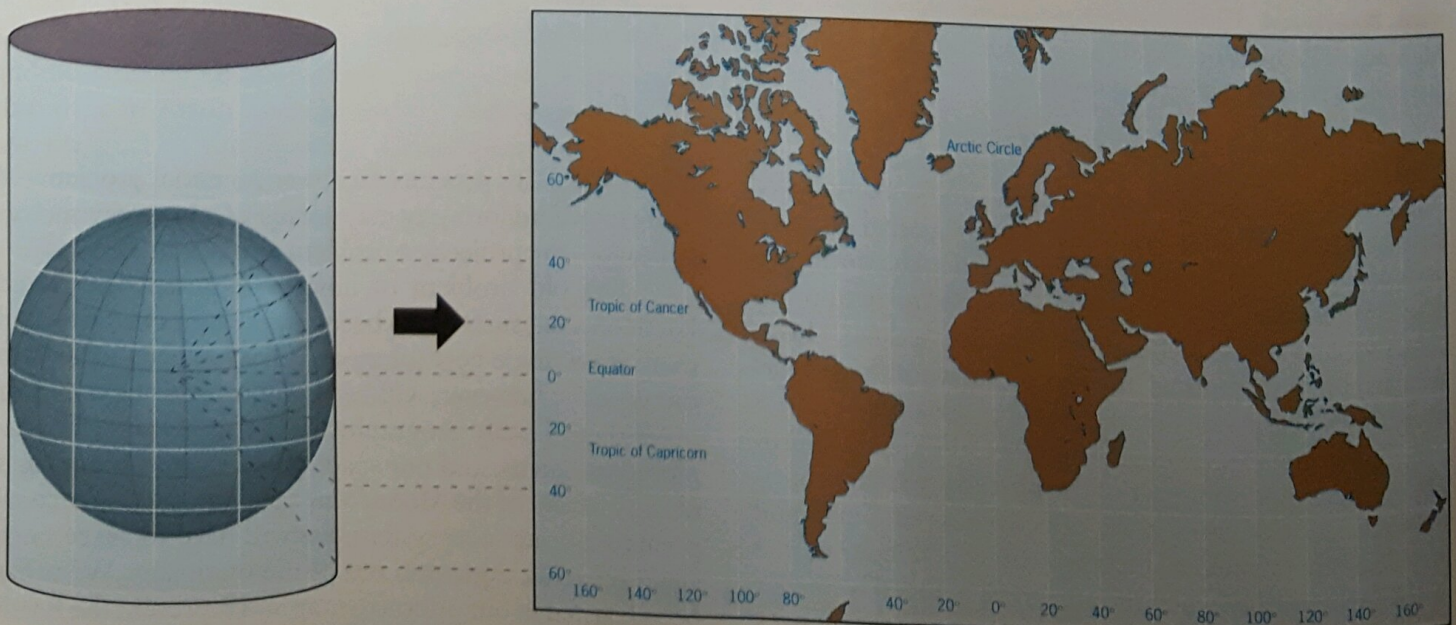
Figure A.6
Shadows of the globe's grid lines on wraparound paper: a **cylindrical projection** results.
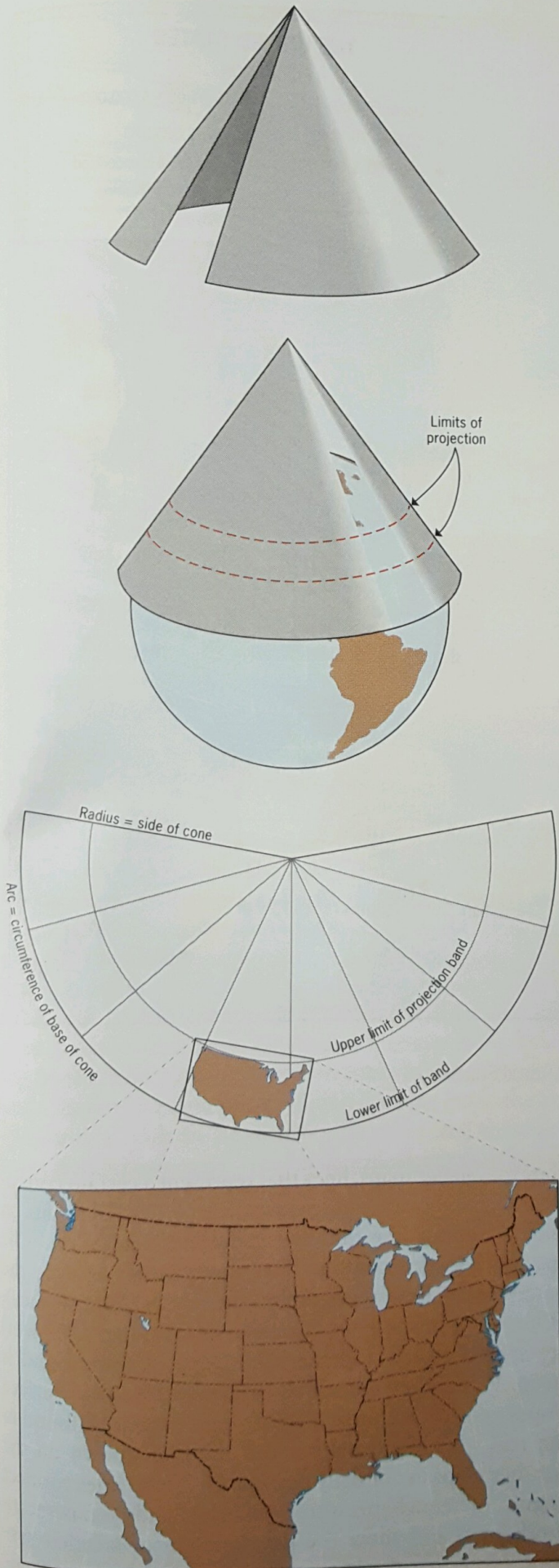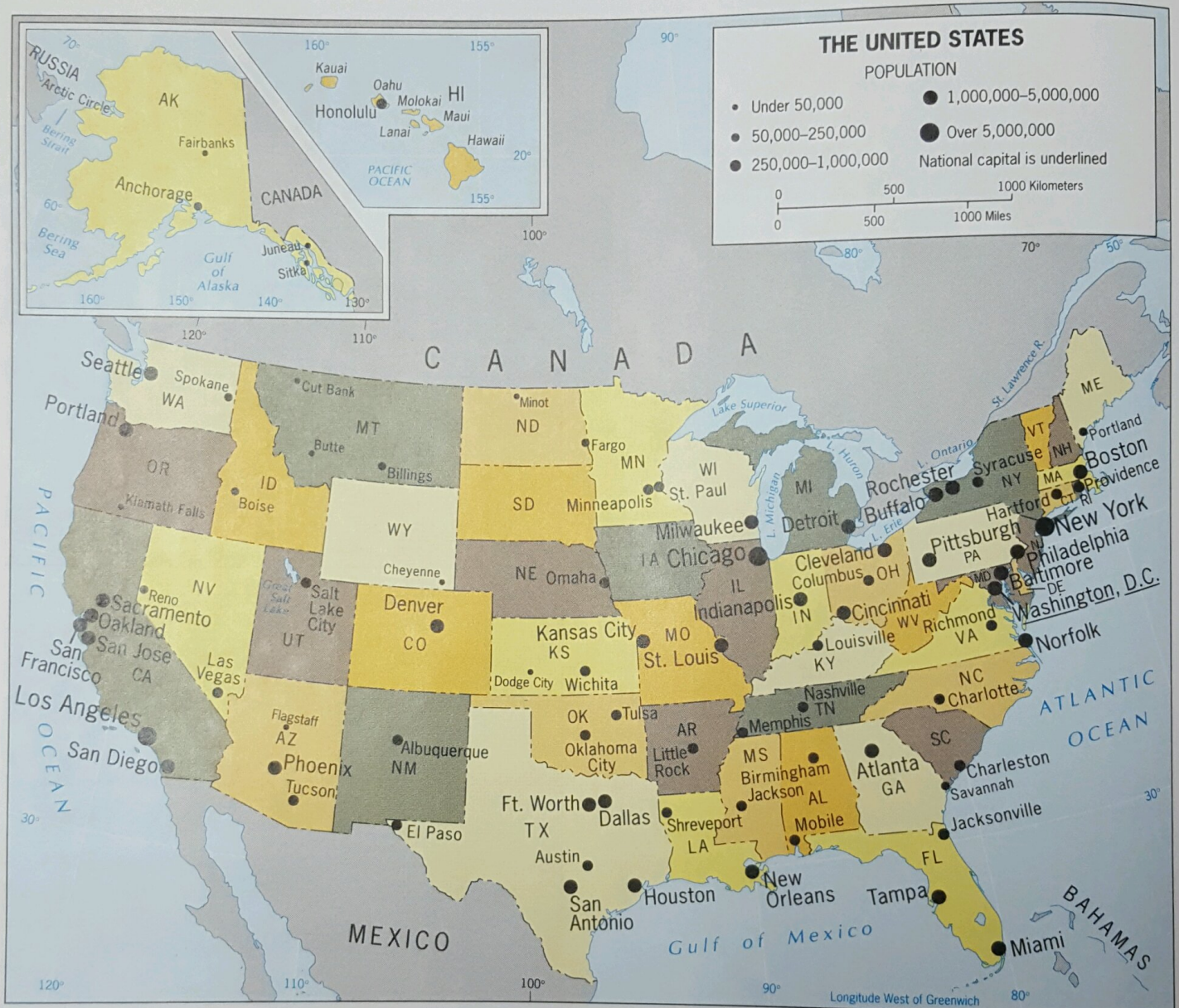
Figure A.7
Construction of a **conic projection**.

Figure A.8
Planar projection: now the light a the center of the globe projects diverging longitude lines on a flat sheet of paper placed over the North Pole (top) and the South Pole (bottom).

come a very complex topic when it comes to highly specialized cartography in such fields as geology and meteorology. Nevertheless, it is useful to know why symbols such as those used on the maps in this book were chosen.

Point symbols, as we noted, are used to show individual features or places. On a large-scale map of a city block, dots can represent individual houses. But on a small-scale map, a dot has to represent an entire "city." Still, cities have various sizes, and those size differences

Figure A.9
This map uses **dot symbols** to indicate size categories of cities in the United States.

can be put in categories and mapped accordingly (Fig. A.9). Thus New York, Chicago, and Los Angeles still appear as dots on the map, but their dots are larger than those representing Tucson, Milwaukee, or Denver. A dimensional scale is added to the map's graphic scale, and at a glance we can see the relative sizes of major cities in the United States and Canada.

Line symbols include not only roads and railroads, but also political and administrative boundaries, rivers, and other linear features. Again scale plays its crucial role: on a large-scale map, it is possible to represent the fenced boundaries of a single farm, but on a small-scale map, such detail cannot be shown.

Some lines on maps do not actually exist on the ground. When physical geographers do their field work

they use *contour* maps, lines that represent a certain consistent height above mean sea level (Fig. A.10). All points on such a contour line thus are at the same elevation. The spacing between contour lines immediately reveals the nature of the local topography (the natural land surface). When the contour lines at a given interval (e.g., 100 feet) are spaced closely together, the slope of the ground is steep. When they are widely separated, the land surface slopes gently. Of course contour lines cannot be found in the real world, and neither can the lines drawn on the weather maps in our daily newspaper. These lines connect points of equal pressure (isobars) and temperature (isotherms) and show the development of weather systems. Note that the letters iso (meaning "the same") appear in these terms. Invisible lines of this kind are collec-
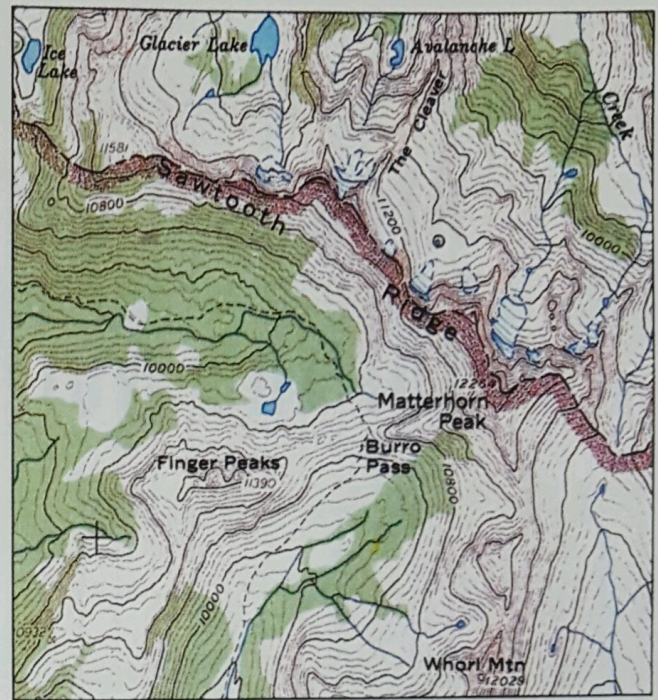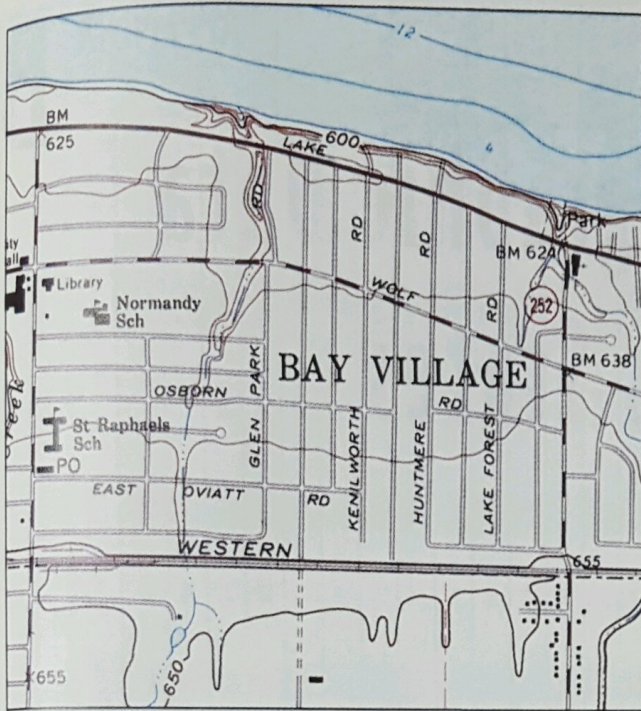
■ Figure A.10

Contour **lines** reflecting low relief (left) and high relief (right). The map at left is part of the U.S.G.S. North Olmstead Quadrangle, Ohio; the map at right is part of the U.S.G.S. Matterhorn Peak Quadrangle, California.

tively known as **isolines**, lines of equal or constant value. These are abstract constructions, but they can be of great value in geographic research and representation.

Area symbols take many forms, and we will see some of them on the maps in this book. Area symbols are used in various ways to represent distributions and magnitudes. Maps showing distributions (of such phenomena as regionally dominant languages or religions in human geography, and climates or soils in physical geography) show the world, or parts of it, divided into areas shaded or colored in contrasting hues. But be careful: those sharp dividing lines are likely to be transition zones in the real world, and a dominant language or religion does not imply the exclusion of all others. So distribution maps, and there are many in this book, tend to be small-scale generalizations of much more complex patterns than they can reveal. Again, maps showing magnitudes also must be read with care.

Here the objective is to reveal *how much* of a phenomenon prevails in one unit (e.g., country) on the map, compared to others. The maps on population in Part Two are examples of such maps. The important cartographic decision has to do with color (or, in black and white, graytones). Darker should mean more, and lighter implies less. That is relatively easily done when the dominant color is the same. But on a multicolored map, the use of reds, greens, and yellows can be confusing, and first impressions may have to be revised upon examination of the key.

Some students who are first drawn to the discipline of geography go on to become professional cartographers, and their work is seen in atlases, foldout magazine maps, books, and many other venues. Although cartographic technology is changing, the world's great atlases and maps still are designed and produced by researchers, compilers, draughtspeople, and other specialists.