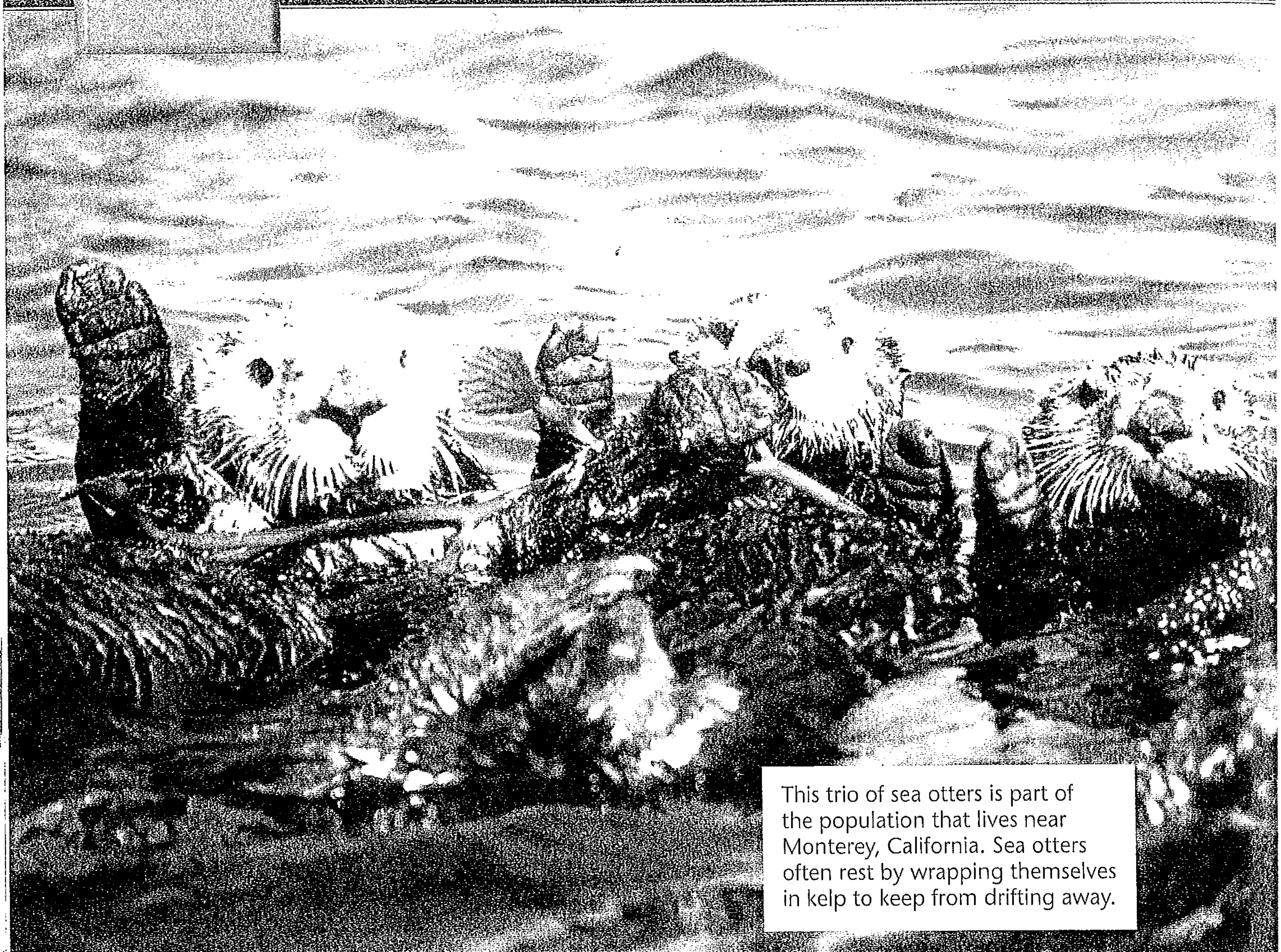
CHAPTER 5

Populations



This trio of sea otters is part of the population that lives near Monterey, California. Sea otters often rest by wrapping themselves in kelp to keep from drifting away.

Inquiry Activity

How do populations grow?

Procedure

1. Assume that a pair of rabbits produces 6 offspring, and that half the offspring are male and half are female. Assume that no offspring die. If each pair of rabbits breeds only once, how many offspring would be produced each year for 5 years?
2. Construct a graph of your data. Plot time on the *x*-axis and population on the *y*-axis.

Think About It

1. **Using Tables and Graphs** Describe the shape o your graph.
2. **Using Tables and Graphs** Use your graph to predict the population of rabbits in 10 years and ir 20 years.
3. **Formulating Hypotheses** How can you explain the fact that Earth is not covered by rabbits?

5–1 How Populations Grow

Sea otters are important members of the kelp forest community of America's Pacific Northwest coast. This "forest" is made up of algae called giant kelp, with stalks up to 30 meters long, and smaller types of kelp. The kelp forest provides a habitat as well as a food source for a variety of animals. Sea otters need a lot of energy to stay warm in cold water, so they eat large quantities of their favorite food: sea urchins. Sea urchins, in turn, feed on kelp.

The relationships along this food chain set the stage for a classic tale of population growth and decline. A century ago, otters were nearly eliminated by hunting. Sea urchin populations increased greatly, and kelp forests nearly disappeared. Why? Because the kelp was eaten down to the bare rock by hordes of sea urchins! The future of the kelp forests looked grim. Then, sea otters were declared an endangered species and were protected from hunting. With hunters out of the picture, otter populations recovered. Sea urchin numbers dropped dramatically. Kelp grew back. But now, some otter populations are shrinking again because otters are being eaten by killer whales. To better understand why populations such as these change as they do, we turn to the study of population biology.

Guide for Reading

Key Concepts

- What characteristics are used to describe a population?
- What factors affect population size?
- What are exponential growth and logistic growth?

Vocabulary

population density
immigration
emigration
exponential growth
logistic growth
carrying capacity

Reading Strategy: Asking Questions Before you read, rewrite the headings in the section as *how, why,* or *what* questions about populations. As you read, write down the answers to your questions.

Characteristics of Populations

Several terms can be used to describe a population in nature. **Three important characteristics of a population are its geographic distribution, density, and growth rate.** A fourth characteristic, the population's age structure, will be discussed later in this chapter. Geographic distribution, or range, is a term that describes the area inhabited by a population. The range can vary in size from a few cubic centimeters occupied by bacteria in a rotting apple to the millions of square kilometers occupied by migrating whales in the Pacific Ocean.

Population density is the number of individuals per unit area. This number can vary tremendously depending on the species and its ecosystem. The population of saguaro cactus in the desert plant community shown in **Figure 5–1,** for example, has a low density, whereas other plants in that community have a relatively high density.

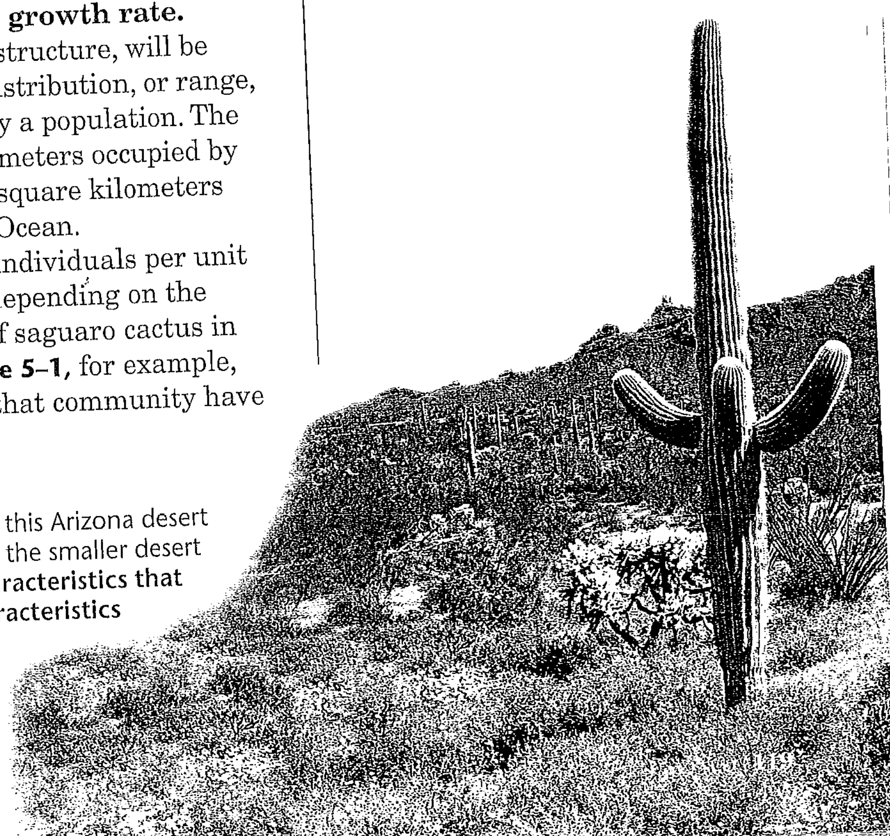


Figure 5–1 The tall saguaro cactuses in this Arizona desert have a low population density compared to the smaller desert plants. **Density is one of the main characteristics that describe a natural population. Other characteristics of populations are their geographic distribution and growth rate.**

Word Origins

Immigration is formed from the Latin prefix *in-*, meaning "in," and *migrare*, meaning "to move from one place to another." **If the Latin prefix *e-* means "out," then what does *emigration* mean?**

▼ **Figure 5–2** This king penguin population has grown in size due to the recent births of chicks, recognizable by their downy brown feathers. **Population size is affected by the number of births, the number of deaths, and the number of individuals that enter or leave the population.**

Population Growth

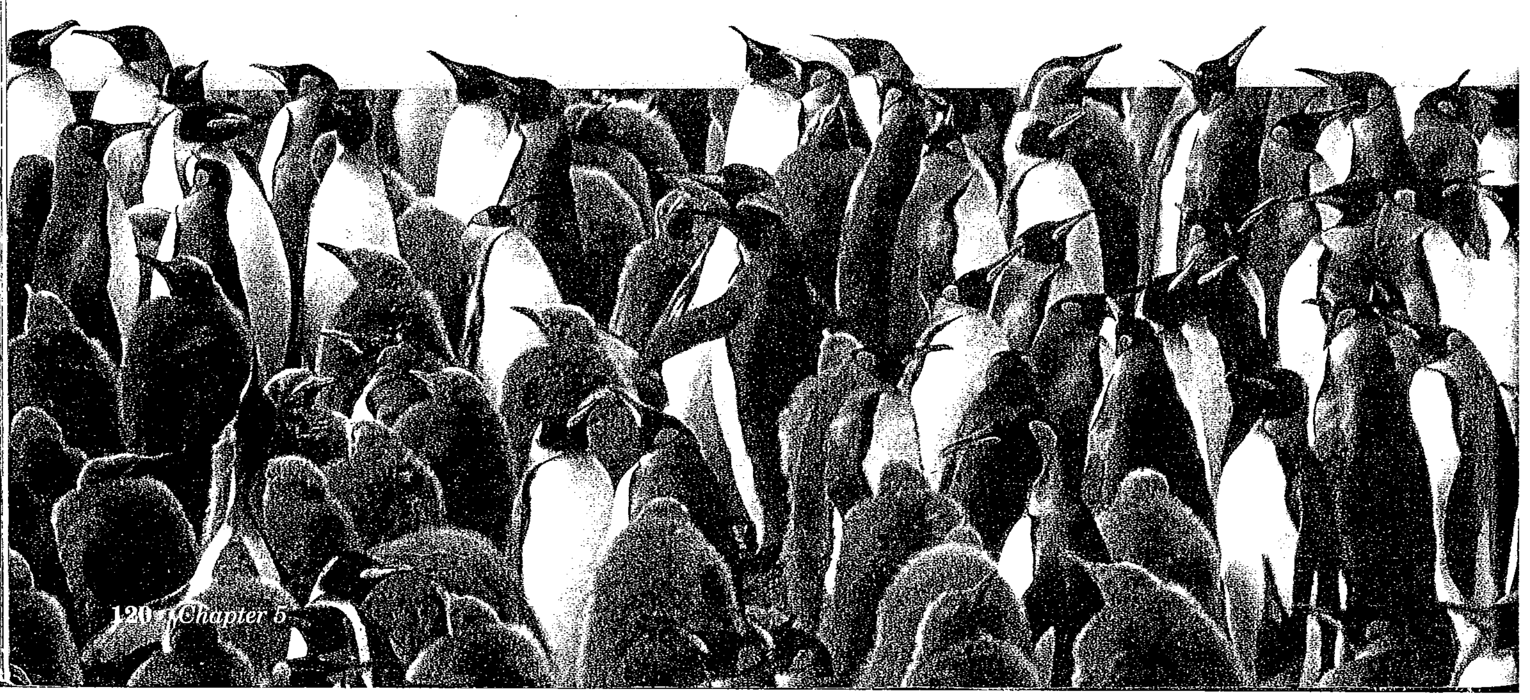
Natural populations may stay the same size from year to year. But a population can grow rapidly, as sea otter populations did when they were first protected from hunting. Populations can also decrease in size, as otter populations are doing now because of predation by killer whales. But just how do interacting factors such as these influence population growth?

Three factors can affect population size: the number of births, the number of deaths, and the number of individuals that enter or leave the population. Simply put, a population will increase or decrease in size depending on how many individuals are added to it or removed from it.

Generally, populations grow if more individuals are born than die in any period of time. For some organisms, such as the penguins in **Figure 5–2**, being born may actually mean hatching. Plants can add new individuals as seeds sprout and begin to grow.

A population can grow when its birthrate is greater than its death rate. If the birthrate equals the death rate, the population stays more or less the same size. If the death rate is greater than the birthrate, the population shrinks. Sea otter populations grew when hunting stopped, because their death rate dropped. Those same otter populations are shrinking now because killer whales have raised the death rate of otters again.

Immigration (im-uh-GRAY-shun), the movement of individuals into an area, is another factor that can cause a population to grow. **Emigration** (em-uh-GRAY-shun), the movement of individuals out of an area, can cause a population to decrease in size. Wildlife biologists studying changes in populations of animals such as grizzly bears and wolves must consider immigration and emigration. For example, emigration can occur when young animals approaching maturity leave the area where they were born, find mates, and establish new territories. A shortage of food in one area may also lead to emigration. On the other hand, populations can increase by immigration as animals in search of mates or food arrive from outside.



Exponential Growth

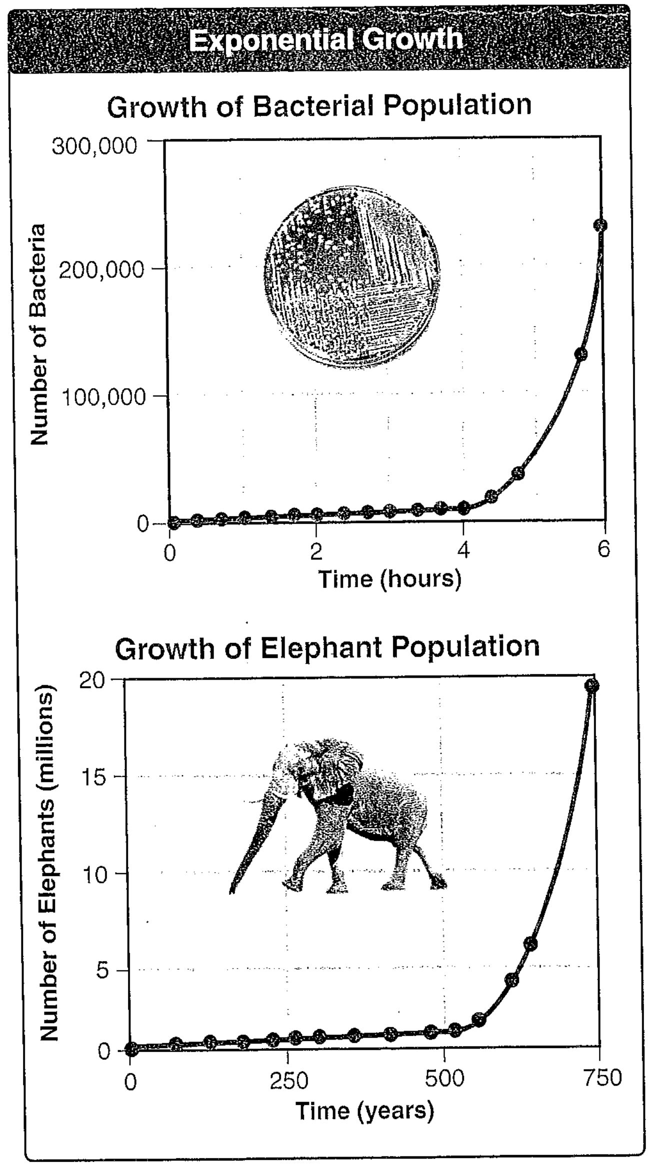
If a population has abundant space and food, and is protected from predators and disease, then organisms in that population will multiply and the population size will increase. Let's conduct an imaginary investigation to understand how growth under ideal conditions might occur. Suppose you put a single bacterium in a petri dish. Supply it with enough nutrients and incubate the culture with the right amount of heat, moisture, and light. How will the population change over time?

Bacteria reproduce by splitting in half. If the bacteria have a doubling time of 20 minutes, then within 20 minutes the first bacterium will divide to produce 2 bacteria. Twenty minutes later, the 2 bacteria will divide to produce 4. After another 20 minutes, there will be 8 bacteria. In another hour, there will be 64 bacteria; and in just one more hour, there will be 512. And in just one day, this colony of bacteria will grow to an astounding size of 4,720,000,000,000,000,000,000. What would happen if this growth pattern continued for several days without slowing down? Bacteria would cover the planet!

Figure 5–3 shows a graph with the size of the bacterial population plotted against time. As you can see, the pattern of growth is a J-shaped curve. The J-shaped curve indicates that the population is undergoing exponential (eks-poh-NEN-shul) growth. **Exponential growth** occurs when the individuals in a population reproduce at a constant rate. At first, the number of individuals in an exponentially growing population increases slowly. Over time, however, the population becomes larger and larger until it approaches an infinitely large size. **Under ideal conditions with unlimited resources, a population will grow exponentially.**

With a doubling time of 20 minutes, some bacteria have the fastest rates of reproduction among living things. Populations of other species grow more slowly. For example, a female elephant can produce an infant only every 2 to 4 years, and then the offspring take about 10 years to mature. But as you can see in **Figure 5–3**, in the unlikely event that all the offspring of a single pair of elephants survived and reproduced for 750 years, there would be nearly 20 million elephants!

✓*CHECKPOINT* *What is exponential growth?*



▲ **Figure 5–3** **In the presence of unlimited resources and in the absence of predation and disease, a population will grow exponentially.** Both hypothetical graphs show the characteristic J-shape of exponential population growth.

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Logistic Growth

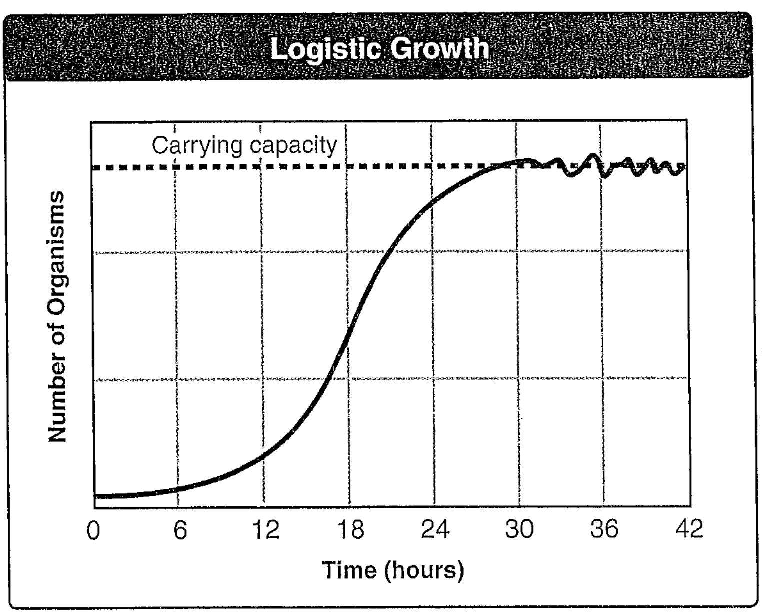
Obviously, neither bacteria nor elephants cover the planet. This means that exponential growth does not continue in natural populations for very long. What might cause population growth to stop or to slow down?

Growth Slows Down Suppose that a few animals are introduced into a new environment. At first, as the animals begin to reproduce, the population increases slowly. Then, because resources are unlimited, the population grows exponentially. In time, however, the rate of population growth begins to slow down. This does not mean that the size of the population has dropped. The population is still growing, but at a much slower rate.

As resources become less available, the growth of a population slows or stops. The general, S-shaped curve of this growth pattern, called logistic growth, is shown in **Figure 5–4** in a yeast population. **Logistic growth** occurs when a population's growth slows or stops following a period of exponential growth. How might this happen?

Population growth may slow down when the birthrate decreases, when the death rate increases, or when both events occur at the same rate. Similarly, population growth may slow down when the rate of immigration decreases, the rate of emigration increases, or both. When the birthrate and death rate are the same, or when the rate of immigration is equal to the rate of emigration, then population growth will slow down or even stop for a time. Note that even when the population growth is said to stop, the population is still rising and falling somewhat, but the ups and downs average out around a certain population size.

▼ **Figure 5–4** This graph shows the S-shaped curve of logistic growth. **As resources become less available, the population growth rate slows or stops.** The growth of this population has leveled off at its carrying capacity.



Carrying Capacity If you look again at **Figure 5–4,** you will see a dotted, horizontal line through the region of the graph where the growth of the yeast population has leveled off. The point at which that line intersects the y-axis tells you the size of the population when the average growth rate reaches zero. That number, in turn, represents the largest number of individuals—in this case, yeast cells—that a given environment can support. Ecologists call this number the **carrying capacity** of the environment for a particular species.

If you examine natural populations of familiar plant and animal species, you will find that many of them follow a logistic growth curve. In the natural world there are many factors that can slow the growth of a population. The factors that limit population growth are discussed in the next section.

Analyzing Data

Population Trends

Do fruit flies and rabbits show similar trends in population growth?

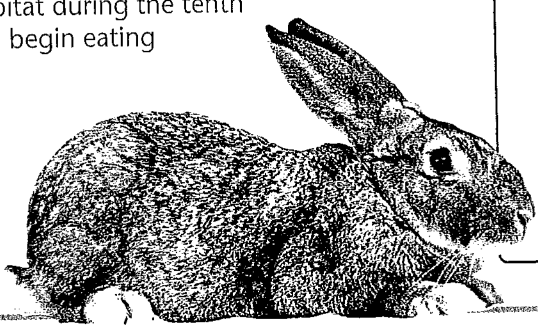
1. **Using Tables and Graphs** Make a graph using the data in each data table. One graph will show the growth rate of a fruit fly population. The other graph will show the growth rate of a population of rabbits.
2. **Using Tables and Graphs** What type of growth pattern is exhibited by the fruit fly population? Is it the same type of growth as in the rabbit population? Explain.
3. **Drawing Conclusions** Does either graph indicate that there is a carrying capacity for the population? If so, when does the population reach its carrying capacity? What is the maximum number of individuals that can be supported at that time?
4. **Predicting** Animals such as foxes and cats often prey on rabbits. Based on the growth curve of the rabbit population, what might happen if a group of predators move into the rabbits' habitat during the tenth generation and begin eating the rabbits?

Fruit Fly Population Growth

Days	Number of Fruit Flies
5	10
10	50
15	100
20	200
25	300
30	310
35	320
40	320

Rabbit Population Growth

Generations	Number of Rabbits
1	100
2	105
25	1000
37	1600
55	2400
72	3350
86	8000
100	13,150



5–1 Section Assessment

1. **Key Concept** List three characteristics that are used to describe a population.
2. **Key Concept** What factors can change a population's size?
3. **Key Concept** What is the difference between exponential growth and logistic growth?
4. What is meant by population density?
5. Define carrying capacity.
6. **Critical Thinking Inferring** What factors might cause the carrying capacity of a population to change?

Thinking Visually

Using Graphic Organizers
Draw a concept map that shows how populations grow. Include the following terms: *exponential growth, logistic growth, birthrate, death rate, immigration, emigration.* Add any other terms that you think are useful to complete the map.

5–2 Limits to Growth

Guide for Reading

Key Concept
- What factors limit population growth?

Vocabulary
limiting factor
density-dependent limiting factor
predator-prey relationship
density-independent limiting factor

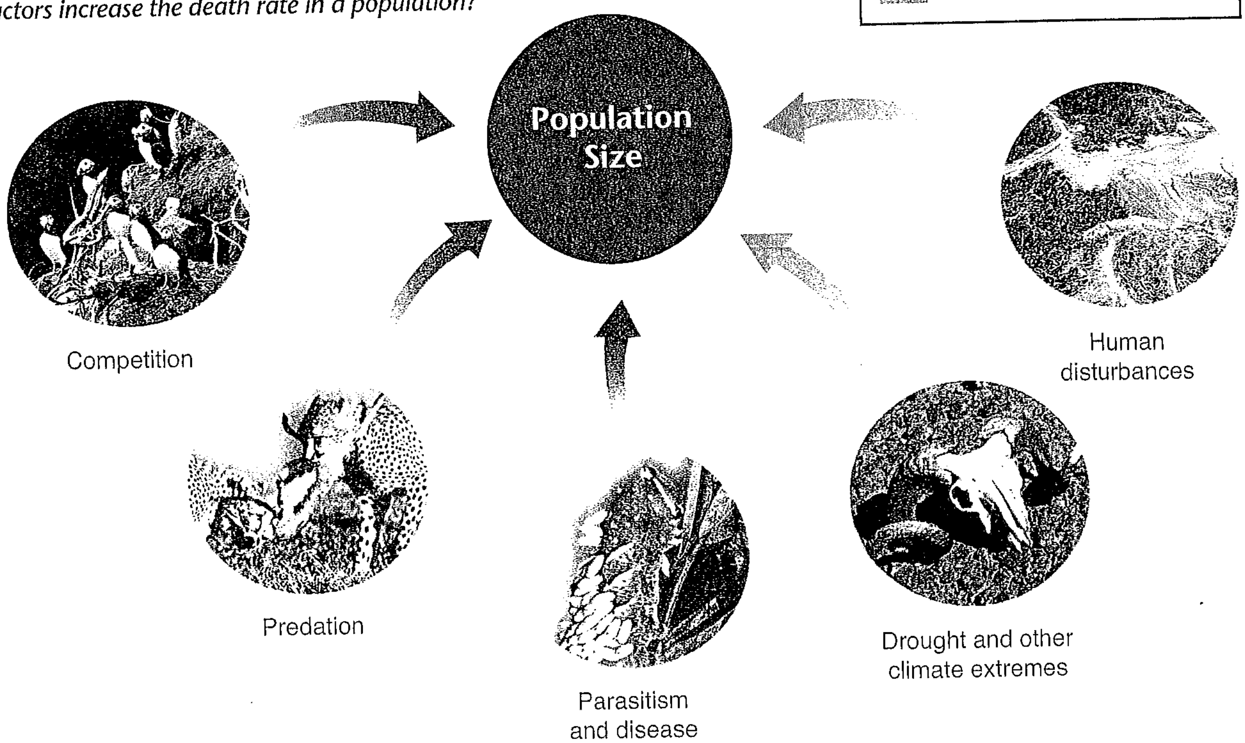
Reading Strategy: Predicting Before you read, preview the diagram below. Predict how each factor might limit the growth of a population. As you read, note whether your predictions were correct.

Now that you know a few things about population growth, think again about the sea otter example in the beginning of the previous section. When a sea otter population declines, something has changed the relationship between the birthrate and the death rate, or between the rates of immigration and emigration. For instance, in part of the sea otter's range, the death rate of sea otters is increasing because killer whales are eating the otters. Predation by killer whales creates a situation that reduces the growth of the sea otter population.

Limiting Factors

Recall from Chapter 3 that the primary productivity of an ecosystem can be reduced when there is an insufficient supply of a particular nutrient. Ecologists call such substances limiting nutrients. A limiting nutrient is an example of a more general ecological concept: a limiting factor. In the context of populations, a **limiting factor** is a factor that causes population growth to decrease. Some of the limiting factors that can affect a population are shown in **Figure 5–5.**

▼ **Figure 5–5** Many different factors can limit population growth. Some of these factors are shown below. **Inferring** *How might each of these factors increase the death rate in a population?*



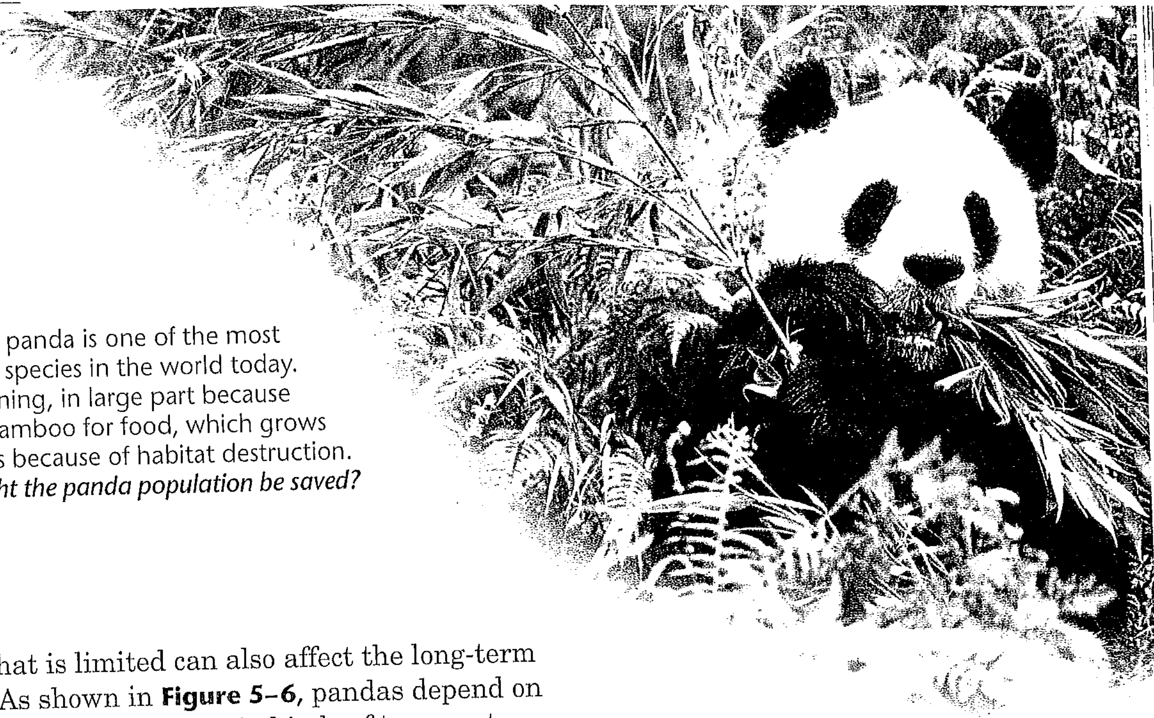


Figure 5–6 The panda is one of the most critically endangered species in the world today. Populations are declining, in large part because pandas depend on bamboo for food, which grows only in certain forests because of habitat destruction. **Inferring** *How might the panda population be saved?*

A resource base that is limited can also affect the long-term survival of a species. As shown in **Figure 5–6**, pandas depend on bamboo for food. Bamboo grows in certain kinds of temperate forests in China. Since the time that these forests have been cleared for timber and farmland, panda populations have fallen dramatically and have become isolated in small pockets of remaining forest.

Density-Dependent Factors

A limiting factor that depends on population size is called a **density-dependent limiting factor.** Density-dependent factors become limiting only when the population density—the number of organisms per unit area—reaches a certain level. These factors operate most strongly when a population is large and dense. They do not affect small, scattered populations as greatly. **Density-dependent limiting factors include competition, predation, parasitism, and disease.**

Competition When populations become crowded, organisms compete with one another for food, water, space, sunlight, and other essentials. For example, puffins must compete for limited nesting sites. Competition among members of the same species is a density-dependent limiting factor. The more individuals living in an area, the sooner they use up the available resources. Likewise, the fewer the number of individuals, the more resources are available to them and the less they must compete with one another.

Competition can also occur between members of different species. This type of competition is a major force behind evolutionary change. When two species compete for the same resources, both species are under pressure to change in ways that decrease their competition. Over time, the species may evolve to occupy separate niches. That is because, as you may recall, no two species can occupy the same niche in the same place at the same time.

CHECKPOINT *What is a density-dependent limiting factor?*

Quick Lab

How does competition affect growth?

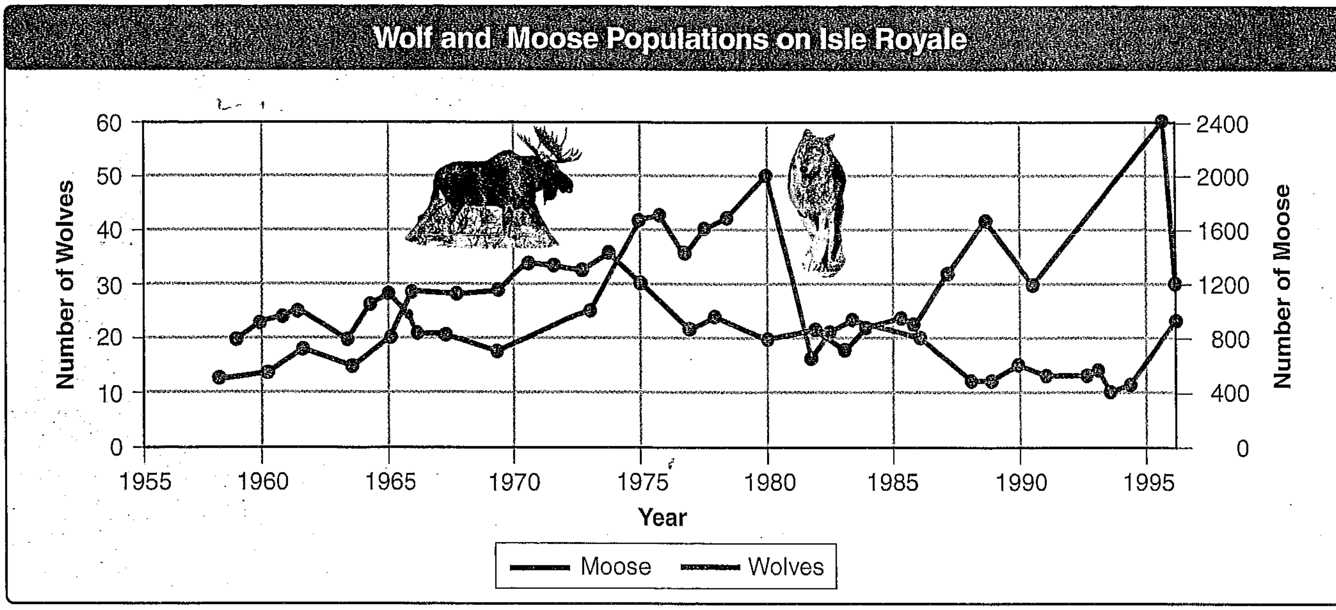
Materials bean seeds, 2 paper cups, potting soil

Procedure

1. Label two paper cups 3 and 15. Use a pencil to make several holes in the bottom of each paper cup. Fill each paper cup two-thirds full with potting soil. Plant 3 bean seeds in cup 3, and plant 15 bean seeds in cup 15.
2. Water both cups so that the soil is moist but not wet. Put them in a location that receives bright indirect light. Water the cups equally as needed.
3. Count the seedlings every other day for 2 weeks. **CAUTION:** *Wash your hands with soap and warm water before leaving the lab.*

Analyze and Conclude

Observing What differences did you observe between the two cups?



▲ **Figure 5–7** The relationship between moose and wolves on Isle Royale illustrates how predation can affect population growth. In this example, the moose population was also affected by changes in food supply, and the wolf population was also affected by disease.

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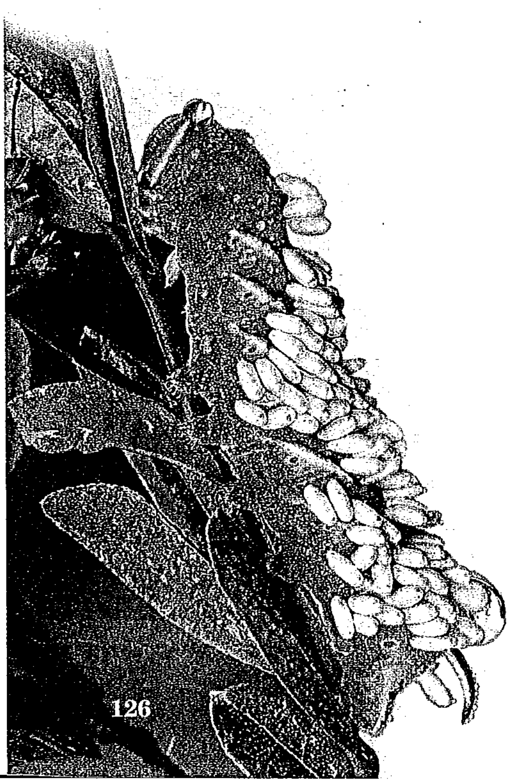
Predation Populations in nature are often controlled by predation. The regulation of a population by predation takes place within a **predator-prey relationship,** one of the best-known mechanisms of population control. The relationships between sea otters and sea urchins and between sea otters and killer whales are examples of predator-prey interactions that affect population growth.

A well-documented example of a predator-prey relationship is the interaction between wolves and moose on Isle Royale, an island in Lake Superior. The graph in **Figure 5–7** shows how periodic increases in the moose population—the prey—on Isle Royale are quickly followed by increases in the wolf population—the predators. As the wolves prey on the moose, the moose population falls. The decline in the moose population is followed, sooner or later, by a decline in the wolf population because there is less for the wolves to feed upon. A decline in the wolf population means that the moose have fewer enemies, so the moose population rises again. This cycle of predator and prey populations can be repeated indefinitely.

Parasitism and Disease Parasites can also limit the growth of a population. Parasitic organisms range in size from microscopic, disease-causing bacteria to tapeworms 30 centimeters or more in length. These organisms are similar to predators in many ways. Like predators, parasites take nourishment at the expense of their hosts, often weakening them and causing disease or death. The wasp cocoons in **Figure 5–8,** for example, can weaken or kill many caterpillars.



◀ **Figure 5–8** This larval sphinx moth has been attacked by a parasitic wasp. The wasp inserted its eggs beneath the moth's skin. After hatching, the wasp larvae fed on their host internally until they appeared as white cocoons on its back. **Predicting** *How might the wasp larvae affect the sphinx moth population?*

Density-Independent Factors

Density-independent limiting factors affect all populations in similar ways, regardless of the population size. **Unusual weather, natural disasters, seasonal cycles, and certain human activities—such as damming rivers and clear-cutting forests—are all examples of density-independent limiting factors.** In response to such factors, many species show a characteristic crash in population size. After the crash, the population may soon build up again, or it may stay low for some time.

For some species, storms or hurricanes can nearly extinguish a population. For example, thrips, aphids, and other insects that feed on plant buds and leaves might be washed out by a heavy rainstorm. Extremes of cold or hot weather also can take their toll on a population, regardless of the population's density. A severe winter frost, for example, can kill giant saguaro cactuses in the Arizona desert. In some areas, periodic droughts can affect entire populations of vegetation, as shown in **Figure 5–9.** Such events can, in turn, affect the populations of consumers within the food web.

Environments are always changing, and most populations can adapt to a certain amount of change. Populations often grow and shrink in response to such changes. Major upsets in an ecosystem, however, can lead to long-term declines in certain populations. Human activities have caused some of these major upsets, as you will soon read.

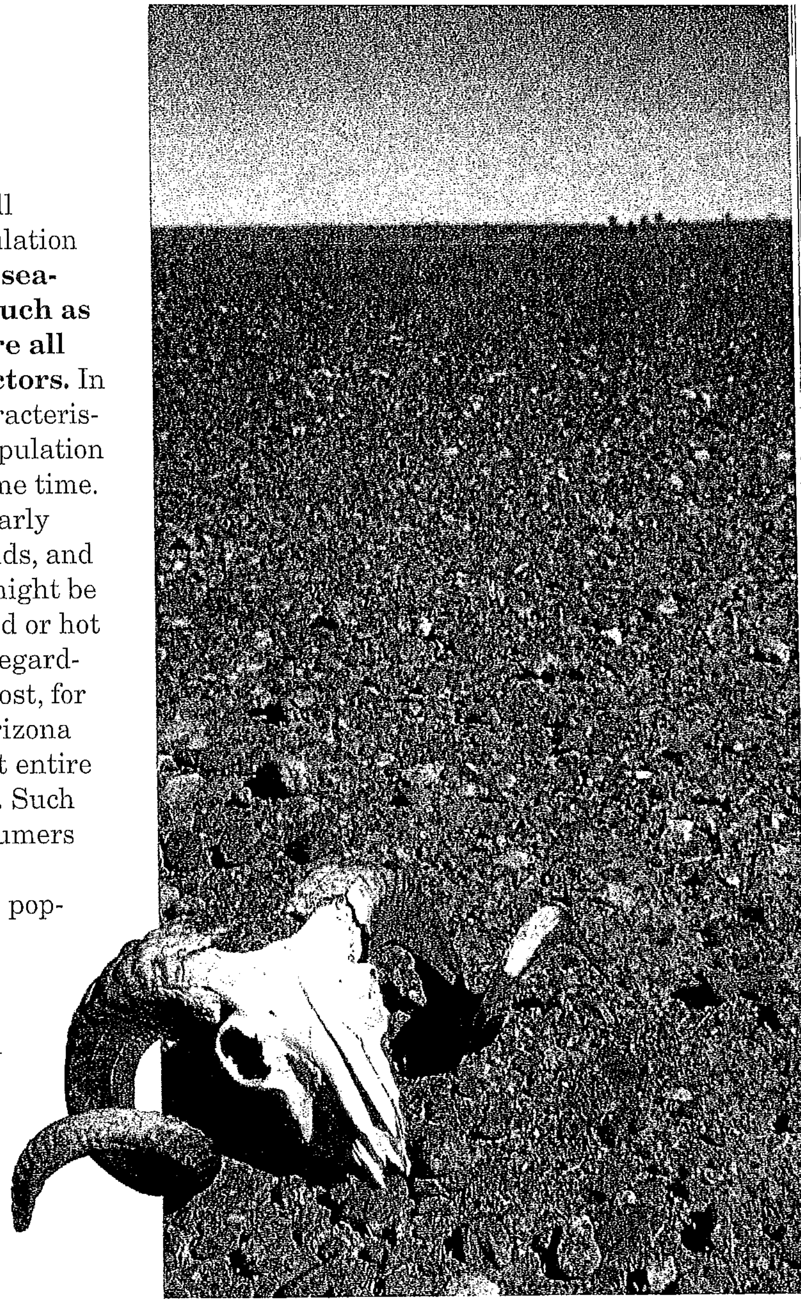


Figure 5–9 A drought can result in the abrupt decrease of a population, regardless of its size. **Droughts and other natural disasters are density-independent limiting factors.**

5–2 Section Assessment

1. **Key Concept** List three density-dependent factors and three density-independent factors that can limit the growth of a population.
2. What is the relationship between competition and population size?
3. If an entire lynx population disappears, what is likely to happen to the hare population on which it preys?
4. Identify how a limited resource can affect the size of a population. Give an example that illustrates this situation.
5. **Critical Thinking Applying Concepts** Give an example of a density-independent limiting factor that has affected a human population. Describe how this factor changed the human population.

Focus on the BIG Idea

Interdependence in Nature Study the factors that limit population growth as shown in **Figure 5–5.** Classify each factor as either biotic or abiotic. Refer to the information on biotic and abiotic factors in Section 4–2.

5–3 Human Population Growth

How quickly is the world's human population growing? In the United States and other developed countries, the current growth rate is very low. In some developing countries, the human population is growing at a rate of nearly 3 people per second. Because of this bustling growth rate, the human population is well on its way to reaching 9 billion within your lifetime.

Guide for Reading

Key Concepts
- How has the size of the human population changed over time?
- Why do population growth rates differ in countries throughout the world?

Vocabulary
demography
demographic transition
age-structure diagram

Reading Strategy: Asking Questions Before you read, preview the graphs in **Figures 5–10**, **5–12**, and **5–13.** Make a list of questions about the graphs. As you read, write down the answers to your questions.

Historical Overview

Like the populations of many other living organisms, the size of the human population tends to increase with time. For most of human existence, the population grew slowly. Life was harsh, and limiting factors kept population sizes low. Food was scarce. Incurable diseases were rampant. Until fairly recently, only half the children in the world survived to adulthood. Because death rates were so high, families had many children, just to make sure that some would survive.

About 500 years ago, the human population began growing more rapidly. Agriculture and industry made life easier and safer. The world's food supply became more reliable, and essential goods could be shipped around the globe. Improved sanitation, medicine, and healthcare dramatically reduced the death rate and increased longevity. At the same time, birthrates in most places remained high. With these advances, the human population experienced exponential growth, as shown in **Figure 5–10.**

▼ **Figure 5–10** **The size of the human population has increased over time.** After a long, slow start, the worldwide population grew exponentially following improvements in medicine, sanitation, agriculture, energy use, and technology.

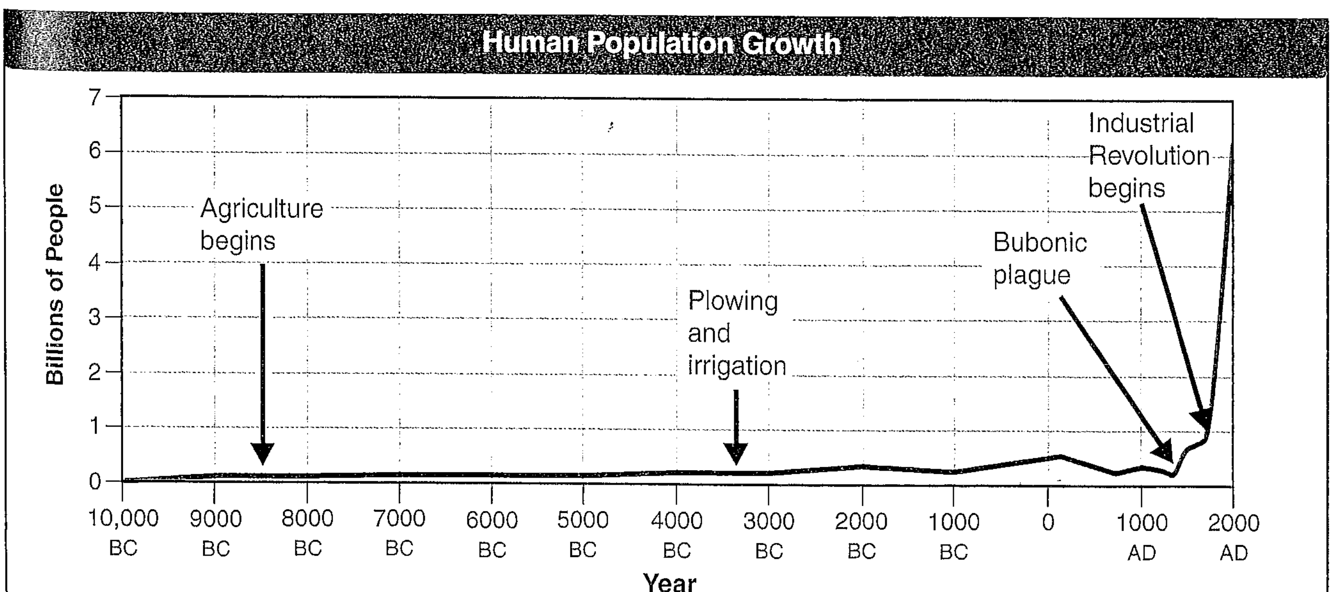


Figure 5–11 Medical advances can lead to a dramatic drop in a population's death rate. Dr. Leila Denmark (near right), who practiced medicine for 73 years, helped to invent the whooping cough vaccine in 1936. A healthcare worker in Rwanda (far right) vaccinates an infant, thereby helping to prevent certain diseases in that child. **Applying Concepts** *Which other advances can reduce a population's death rate?*

Patterns of Population Growth

The human population cannot keep growing exponentially forever, because Earth and its resources are limited. The question is, when and how will our population growth slow? Two centuries ago, English economist Thomas Malthus observed that human populations were growing rapidly. Malthus predicted that such growth would not continue indefinitely. Instead, according to Malthus, war, famine, and disease would limit human population growth.

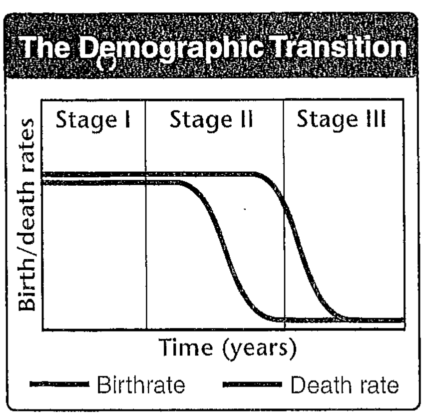
Today, scientists have identified a variety of other social and economic factors that can affect human populations. The scientific study of human populations is called **demography** (duh-MAH-gruh-fee). Demography examines the characteristics of human populations and attempts to explain how those populations will change over time. **Birthrates, death rates, and the age structure of a population help predict why some countries have high growth rates while other countries grow more slowly.**

The Demographic Transition Over the past century, population growth in the United States, Japan, and much of Europe has slowed dramatically. Demographers have developed a hypothesis to explain this shift. According to this hypothesis, these countries have completed the **demographic transition,** a dramatic change in birth and death rates.

Throughout most of history, human societies have had high death rates and equally high birthrates. With advances in nutrition, sanitation, and medicine, more children survive to adulthood and more adults live to old age. These changes lower the death rate and begin the demographic transition.

Figure 5–12 shows that when the death rate first begins to fall, birthrates remain high. During this phase of the demographic transition, births greatly exceed deaths, and population increases rapidly. This was the situation in the United States from 1790 to 1910. Many parts of South America, Africa, and Asia are still in this phase.

As societies modernize, increase their level of education, and raise their standard of living, families have fewer children. As the birthrate falls, population growth slows. The demographic transition is complete when the birthrate falls to meet the death rate, and population growth stops.



▲ **Figure 5–12 Birthrates, death rates, and the age structure of a population help predict the rate of population growth.** Birthrates and death rates fall during the demographic transition. In Stage I, both the birthrate and death rate are high. During Stage II, the death rate drops while the birthrate remains high. Finally, in Stage III, the birthrate also decreases.

So far, the demographic transition has been completed in only a few countries. Despite the trend in the United States, Europe, and Japan, the worldwide human population is still growing exponentially. Most people live in countries that have not yet completed the demographic transition. Much of the population growth today is contributed by only 10 countries, with India and China in the lead, where birthrates remain high.

Age Structure Population growth depends, in part, on how many people of different ages make up a given population. Demographers can predict future growth using models called **age-structure diagrams,** or population profiles. Age-structure diagrams show the population of a country broken down by gender and age group. Each bar in the age-structure diagram represents individuals within a 5-year group. Percentages of males are to the left of the center line and females to the right in each group.

Consider **Figure 5–13,** which compares the age structure of the U.S. population with that of Rwanda, a country in east-central Africa. In the United States, there are nearly equal numbers of people in each age group. This age structure predicts a slow but steady growth rate for the near future. In Rwanda, on the other hand, there are many more young children than teenagers, and many more teenagers than adults. This age structure predicts a population that will double in about 30 years.

✓CHECKPOINT *What are age-structure diagrams?*

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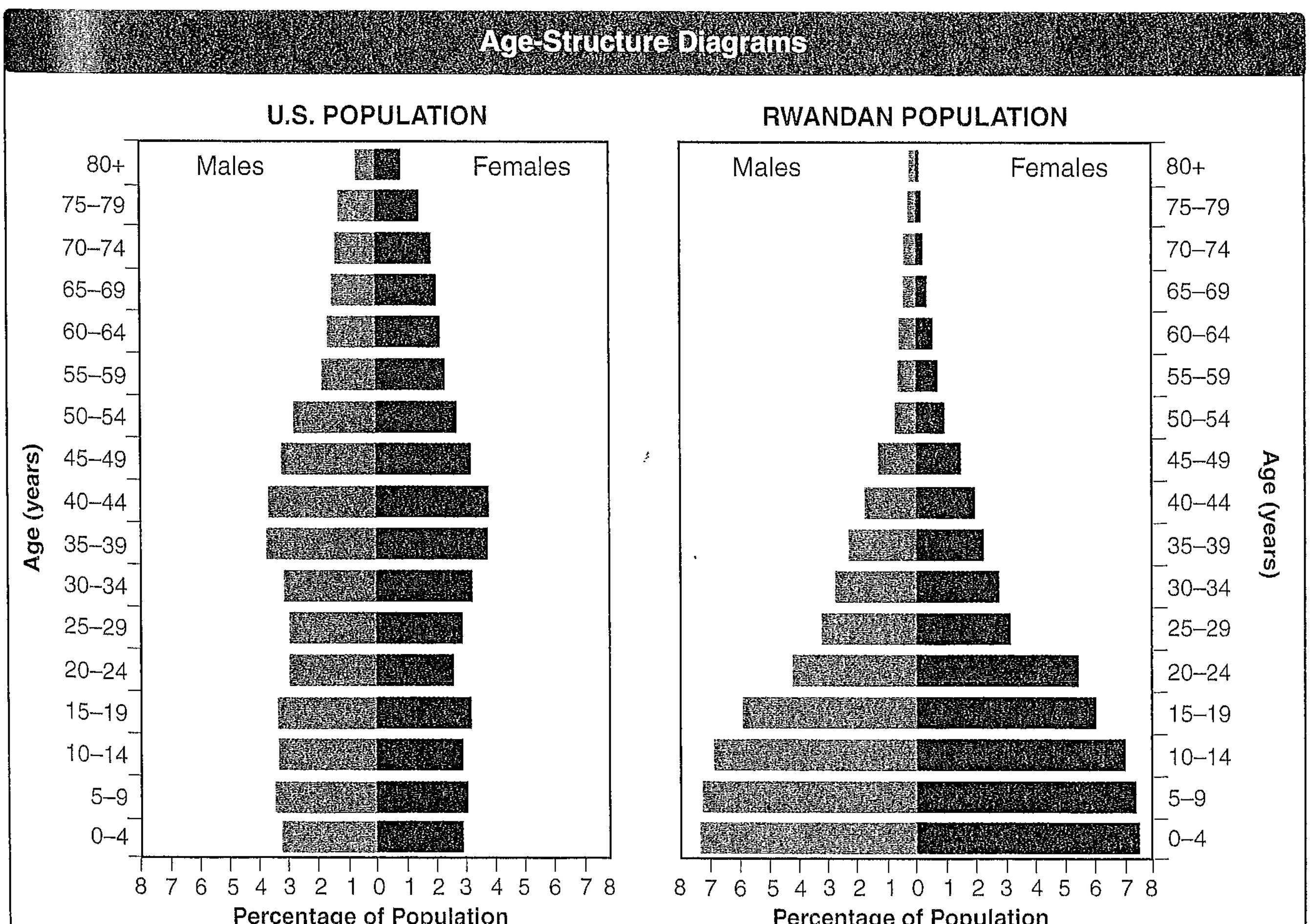
▼ **Figure 5–13** These graphs show the age structure of the U.S. population and the Rwandan population. **Analyzing Data** *How do the United States and Rwanda differ in the percentages of 10- to 14-year-olds in the population?*



World Population: 1950–2050		
Year	Average Annual Growth Rate (%)	Population
1950	1.47	2,555,360,972
1960	1.33	3,039,669,330
1962*	2.19	3,136,556,092
1963*	2.19	3,206,072,286
1970	2.07	3,708,067,105
1980	1.69	4,454,607,332
1990	1.58	5,275,407,789
2000	1.23	6,078,684,329
2010	1.06	6,812,009,338
2020	0.87	7,515,218,898
2030	0.68	8,127,277,506
2040	0.54	8,646,671,023
2050	0.43	9,078,850,714

*Highest growth rate during 100-year period

▲ **Figure 5–14** This table, based on actual and projected data from the U.S. Census Bureau, International Database, shows data on world population. **Predicting** *Based on the projected trend between 2040 and 2050, what might the world population be in 2060?*

Future Population Growth

To predict how the world's human population will grow, demographers must consider many factors, including the age structure of each country and the prevalence of life-threatening diseases, such as AIDS, malaria, and cholera. The table in **Figure 5–14** shows statistics for world population growth from 1950 to 2000 with projected figures through the year 2050. Current projections suggest that by 2050, the world population may reach more than 9 billion people.

Will the human population grow at its current rate, or will it level out to a logistic growth curve and become stable? By 2050 the growth rate may level off or even decrease. This may happen if countries that are currently growing rapidly move toward the demographic transition. The figures in the table show that the growth rate in 2050 is projected to be 0.43 percent. This rate is a decrease from the peak growth rate of 2.19 percent, reached in the early 1960s.

A lower growth rate means that the human population will be growing more slowly over the next 50 years. But, because the growth rate is still larger than zero, our population will continue to grow. Most ecologists suggest that if this growth does not slow down even more, there could be serious damage to the environment as well as to the global economy. On the other hand, many economists assert that science, technology, and changes in society will control those negative impacts on the environment and economy.

5–3 Section Assessment

1. **Key Concept** Describe the general trend of human population growth that has occurred over time.
2. **Key Concept** What factors explain why populations in different countries grow at different rates?
3. What is demography?
4. Describe the demographic transition and explain how it might affect a country's population growth rate.
5. **Critical Thinking Evaluating** Why do you think age-structure diagrams can help predict future population trends?

Writing in Science

Explanatory Writing
Write a paragraph on the trends in the growth of world population from 1950 to 2050. Be sure to distinguish between population growth and population growth rate. *Hint:* Refer to **Figure 5–14** to help with your explanation.