

How Populations Grow

READING TOOL Cause and Effect As you read this lesson, use the graphic organizer to take notes on how both types of population growth occur. Make sure to include notes on birth rates, death rates, and growth rates.

Type of Population Growth		Cause	Effect
Exponential Growth		A species is introduced into a new region with plentiful resources and few predators.	
Logistic Growth	Phase 1	A species is introduced into a new region with plentiful resources and few predators.	
	Phase 2	Resources become limited.	
	Phase 3	The carrying capacity of the environment is reached.	

Lesson Summary

Describing Populations

KEY QUESTION *How do ecologists study populations?*

Ecologists study populations by examining their geographic range, growth rate, density and distribution, and age structure.

Geographic Range The places a population lives make up its geographic range. A population range can vary enormously in size. For example, the population of bacteria in a single rotting vegetable is in a small area. The part of an ocean inhabited by a population of fish can be a very large area. Geographic ranges can grow or shrink over time.

Growth Rate The number of individuals in a population can change over time, or it can stay the same. Population numbers can grow rapidly when moving into a new area, or they can shrink over time due to activities such as hunting.

As you read, circle the answers to each Key Question. Underline any words you do not understand.

Visual Reading Tool: Patterns of Distribution

Individuals in a population can be spaced out randomly, uniformly, or in clumps. Into each box, draw how 16 individuals would be spaced for each type of distribution pattern. Draw each individual as a small circle.



Random



Uniform



Clumped

BUILD Vocabulary

population density number of individuals per unit area

population distribution how individuals are spaced out across their range

age structure the number of males and females of each age in a population

Density and Distribution The number of individuals that can be found per unit area is called the **population density**.

In a given environment, one species may have very few individuals, or a low density, while another species has a much higher density, with many individuals. **Population distribution** is a description of the way individuals are spaced out across the population's range. There are three distribution patterns: random, uniform, and clumped. In a clumped population, individuals are packed closely together. This may, for example, help protect individuals from predators. In a uniform population, individuals are spaced evenly. This occurs when individuals compete for resources. In a random distribution, individuals are spaced unevenly. This occurs when the location of an individual has little effect on another individual.

Age Structure To understand a population, ecologists need to know the age of individuals, and how many are male and how many are female. This information describes the **age structure** of the population, which is important because most plants and animals must reach a certain age to reproduce. For animals, only females can produce offspring.

Population Growth

KEY QUESTION *What factors affect population growth?*

A population will increase or decrease in size depending on how many individuals are added to it or removed from it. Birthrate, death rate, and the rate at which individuals enter or leave a population all affect population growth.

Birthrate and Death Rate Populations can increase if more individuals are born in a period of time than die during the same period. In other words, a population can increase when its birthrate is higher than its death rate. If the birthrate equals the death rate, the population may stay the same size. If the death rate is greater than the birthrate, the population will decrease.

Immigration and Emigration A population may increase if individuals move into its range from elsewhere. This is called **immigration**. A surplus of food can cause immigration. A population may decrease if individuals move out of the population's range. This is called **emigration**, which can be caused by a shortage of food or other resources. Immigration and emigration depend in part on how far and how fast individuals can travel, or whether human activity moves them around.

Exponential Growth

KEY QUESTION *What happens during exponential growth?*

If a population has all of the food and space it needs and protection from predators and disease, the population can increase. The rate of population growth increases because each generation contains more individuals than the generation before it. More and more offspring are produced in a situation called **exponential growth**. Under ideal conditions with unlimited resources, a population will increase exponentially. This means that the larger the population gets, the faster it grows.

Organisms That Reproduce Rapidly Bacteria can grow very rapidly. If a single bacterium in ideal conditions can divide every 20 minutes, then after 20 minutes there are two bacteria, after another 20 minutes there are four bacteria, and at the end of the first hour, there are eight bacteria cells. After three 20-minute periods, there are $2 \times 2 \times 2$, or $2^3 = 8$ cells. In two hours there are $2^6 = 64$ cells. After one day, there are 4720 quintillion cells. If you plot the bacterial population on a graph, you get a curve shaped like the letter J that rises slowly at first and then rises faster and faster. If nothing interfered with this growth, the population would become infinitely large.

Organisms That Reproduce Slowly Most organisms reproduce much more slowly than bacteria. But if exponential growth continued indefinitely, the result would still be an impossible number of individuals.

Organisms in New Environments Sometimes when an organism migrates or is moved to a new location, its population grows exponentially for a time.

BUILD Vocabulary

immigration movement of individuals into an area occupied by an existing population

emigration movement of individuals out of an area

exponential growth growth pattern in which the individuals in a population reproduce at an increasing rate

Prefixes *Immigration* and *emigration* both have the root word *migration*. The prefix *im-* means "into," and the prefix *e-* means "out of." For some uses, the prefix *ex-* is used instead of *e-*. Which word listed below means bringing products into a country from another country? Circle your answer.

Import

Export

BUILD Vocabulary

logistic growth growth pattern in which a population's growth slows and then stops following a period of exponential growth

carrying capacity largest number of individuals of a particular species that a particular environment can support

Word Origins The word *capacity* comes from the latin word *capax* which means "that can contain." Carrying capacity refers to the number of individuals that a certain environment can support.

☑ **What type of population growth will show a population reaching it's carrying capacity?**

Logistic Growth

🔍 **KEY QUESTION** *What happens during logistic growth?*

Phases of Growth Natural populations do not grow exponentially for very long. Sooner or later things happen that stop exponential growth. After a few individuals are introduced into a real-world environment, growth follows the following steps, or phases.

Phase 1: Population Grows Rapidly After a short time, the population begins to grow exponentially. During this phase, resources are unlimited. Individuals grow and reproduce rapidly and few individuals die, and many offspring are produced. The population size and rate of growth increase more and more rapidly.

Phase 2: Growth Slows Down In real-world populations, exponential growth begins to slow down. This slowing down of growth is due to limiting factors such as competition for resources. This does not mean that the population size decreases. The population still increases, but not as rapidly as before.

Phase 3: Growth Stops At some point the rate of population growth decreases to zero. The size of the population levels off and may remain about the same size for a long time.

The Logistic Growth Curve The logistic growth curve is shaped like the letter S. **Logistic growth** occurs when a population's growth slows and then stops, following a period of exponential growth.

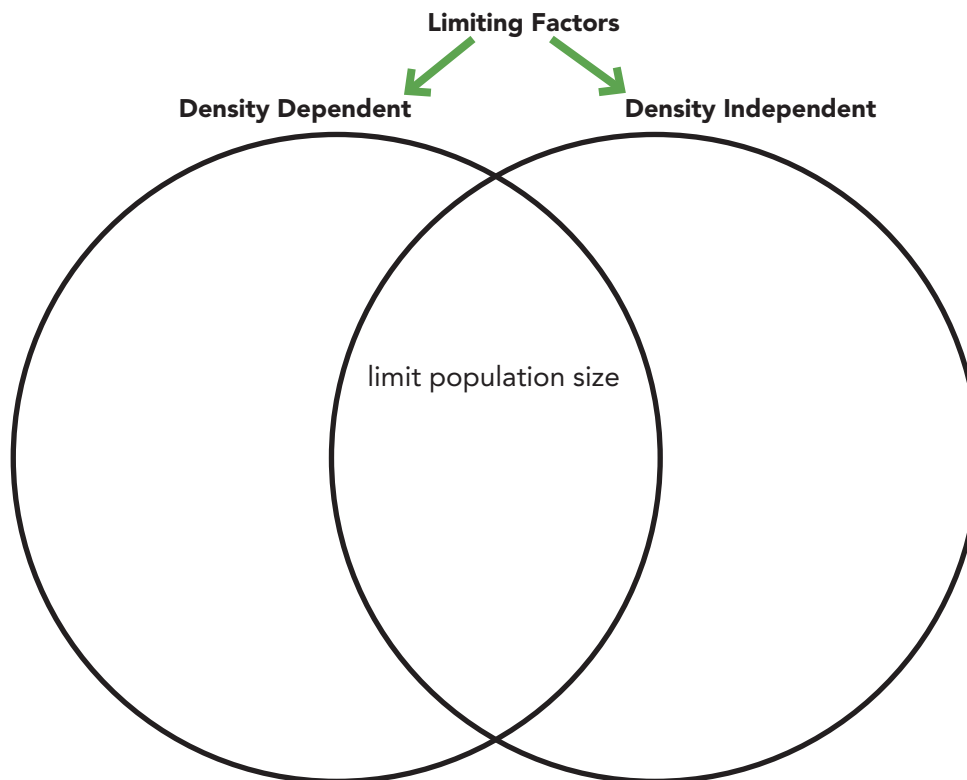
Many plant and animal populations follow a logistic growth curve. Growth may slow if the birthrate decreases or if the death rate increases. Changing rates of immigration and emigration also affect population growth.

Carrying Capacity A population stops growing when its birthrate and death rate are the same, and when immigration equals emigration. The population size may rise and fall somewhat, but the changes average out around a certain population size.

The **carrying capacity** is the maximum number of individuals of a particular species that a particular environment can support. Once a population reaches the carrying capacity of its environment, various factors affect the population and help stabilize its size.

Limits to Growth

READING TOOL Compare and Contrast As you read your textbook, complete the Venn diagram to compare and contrast density-dependent limiting factors and density-independent limiting factors.



Once you have finished the venn diagram, categorize the following scenarios as density-dependent and density-independent limiting factors.

Scenario A: A flood wipes out all the plant species that live on a riverbed.

Scenario B: A pack of wolves migrates to a new valley and eats all the deer that inhabit that space.

Scenario C: A large population of zebras are killed due to a very contagious virus.

Scenario D: A drought kills many of the deer that live in a valley.

Limiting Factor	Density-Dependent	Density-Independent
Scenario(s)		

Lesson Summary

As you read, circle the answers to each Key Question. Underline any words you do not understand.

BUILD Vocabulary

limiting factor factor that causes population growth to decrease

density-dependent limiting factor limiting factor that depends on population density

Using Prior Knowledge You may have encountered *density* in other classes. It is most commonly used to refer to the mass of material in a given volume. For two objects that are the same size, the denser object will have a greater mass. In population ecology, *population density* can refer to the number of individuals per unit area. Examples include the number of penguins on an island, or the number of bacteria living on a rotting vegetable. **When there is a high population density for a species, what do individuals compete for?**

Limiting Factors

KEY QUESTION *What factors determine carrying capacity?*

The growth of primary producers can be controlled by a limiting nutrient. A limiting nutrient is one example of a limiting factor. A **limiting factor** is any factor that controls the growth of a population. Limiting factors are biotic or abiotic environmental factors that affect members of a population. Acting separately or together, limiting factors determine the carrying capacity of an environment for a species. Limiting factors produce the pressures of natural selection at the heart of Charles Darwin's evolutionary theory.

Density-Dependent Limiting Factors

KEY QUESTION *What limiting factors depend on population density?*

Limiting factors that affect a population most strongly when population density reaches a certain level are called **density-dependent limiting factors**. Such factors do not strongly affect small, scattered populations. Density-dependent limiting factors include competition, stress from overcrowding, parasitism, disease, predation, and herbivory.

Competition When populations are crowded, individuals compete for food, water, space, sunlight, and other resources that may be limited. Some individuals may have enough resources to survive and reproduce. Some may have enough to survive, but not to reproduce. Others may die from lack of resources. Competition for resources can decrease birthrates, increase death rates, or both. Competition is density dependent because resources can be used up when there are more individuals. Competition can be between members of the same species, or between species.

Parasitism and Disease Parasites and disease-causing organisms weaken their hosts and can cause death. Parasitism and disease are density-dependent factors because they spread from one host to another more easily when populations are dense.

Stress From Overcrowding Some organisms fight each other if they are overcrowded. Individuals can be weakened and may die. In some species, overcrowding stress can cause animals to neglect or kill their own offspring. Overcrowding stress can lower birthrates, raise death rates, or increase emigration.

Predation and Herbivory The effects of predators on prey or herbivores on plants are density dependent.

Predator-Prey Relationships Populations of predators and prey may rise and fall. When there is plenty of prey, the predator has plenty to eat and may increase in number. This causes the prey death rate to rise higher than its birthrate, so the prey population decreases. As the prey decreases, the predators begin to starve, so the predator population falls. This allows the prey population to start rising again.

Herbivore Effects An herbivore is a predator of a plant. Populations of herbivores and plants cycle up and down, just like populations of predator and prey.

Humans as Predators Human activity may limit populations of other organisms. Hunting is one way that humans can cause large decreases in animal populations.

Density-Independent Limiting Factors

KEY QUESTION *What limiting factors do not typically depend on population density?*

Density-independent limiting factors affect populations regardless of population size and density. Environmental extremes—including weather extremes such as hurricanes, droughts, or floods, and natural disasters such as wildfires—can act as density-independent limiting factors. Such factors may cause a population to “crash,” or reach very small sizes. After a crash, a population may increase again or stay low for a long time. Extreme hot and cold weather and severe drought along with human-caused environmental damage can affect populations of plants and animals.

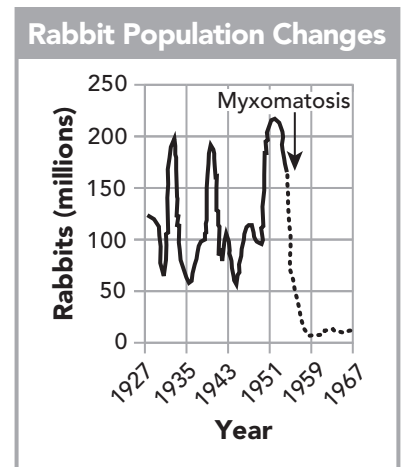
True Density Independence? Bad weather can affect dense populations more than it would affect less dense populations by, for example, making food less available. It is sometimes difficult to say that a limiting factor acts only in a density-independent way.

BUILD Vocabulary

density-independent limiting factor limiting factor that affects all populations in similar ways, regardless of the population density

READING TOOL

Connect to Visuals The graph shows the rabbit population in South Australia before and after a virus, myxomatosis, was introduced to reduce the rabbit population. Use the graph and the information presented in this lesson to answer the questions.



Was the virus a density-dependent or a density-independent limiting factor?

Controlling Introduced Species The number of individuals of a species can increase rapidly when introduced into a new environment. Hunting is not always an effective way to control introduced species. A predator or a pathogen can be introduced to control a population, but if this works, the effect may be only temporary.

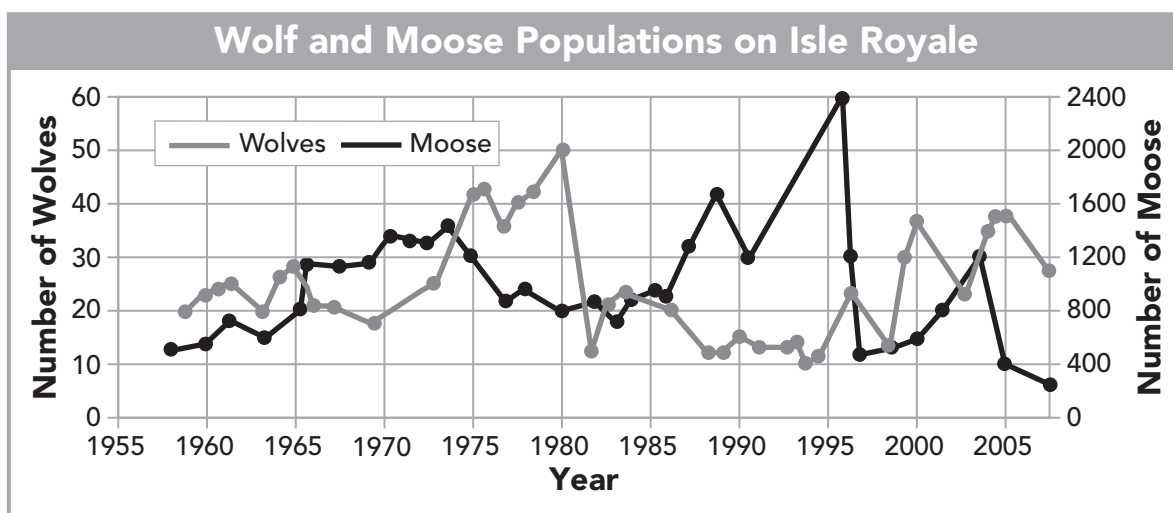
Limiting Factors and Extinction

KEY QUESTION *What is the relationship between limiting factors and extinction?*

Limiting factors such as temperature and rainfall can change over time. Human activity can divide natural environments into smaller pieces, reducing available space and carrying capacity. If carrying capacity falls low enough, populations can be wiped out, leading to species extinction. An extinct species has no members remaining.

Visual Reading Tool: Analyzing Changes in Wolf and Moose Populations

Figure 5-9 shows the populations of wolves and moose on Isle Royale from 1955–2005. Use the data to answer the questions below.

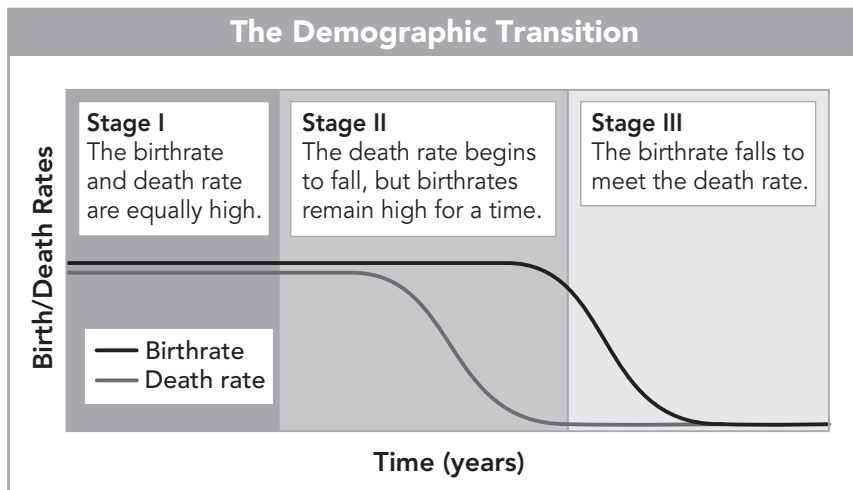


1. Circle the location on the graph where the wolves experienced a steep population decrease. What could have caused this?

2. Why is there a steep increase in Moose from 1985–1995?

READING TOOL Sequence of Events

As you read this lesson, use your workbook to explain the three stages of The Demographic Transition. Look for words like “next” and “lastly” in the text, and use Figure 5-14 to help you enter the correct words to finish each sentence in the graphic organizer.



STAGE 1	STAGE 2	STAGE 3
<ul style="list-style-type: none"> • Death rates and birthrates are both _____. • For most of human history, not all children that were born made it to adulthood. 	<ul style="list-style-type: none"> • Advances in _____, _____, _____ lower death rates . • Birth rates are _____. 	<ul style="list-style-type: none"> • Living standards rise and birthrates _____. • This makes birthrates and death rates _____.

Lesson Summary

Historical Overview

KEY QUESTION How has human population size changed over time?

Human populations can increase, remain the same, or decrease, due to the same factors that affect the population growth of other species. Human populations, like other populations, tend to increase, and the rate of those increases has changed over time. In some countries, population growth is more rapid than in others. For most of human existence, our population grew slowly because predators and disease were common. Until a few decades ago, only half of the children in the world survived to adulthood, so families had many children to make sure that some would survive.

Q As you read, circle the answers to each Key Question. Underline any words you do not understand.

READING TOOL

Academic Words

sanitation prevention of disease by removal of sewage and trash

✓ List some ways that modern cities in developed countries have improved sanitation conditions over the last 200 years. You may use the Internet to research your answers.

BUILD Vocabulary

demography scientific study of human populations

demographic transition change in a population from high birth and death rates to low birth and death rates

Prefixes The prefix *demo-* comes from the Greek word *demos*, meaning “people.” The same prefix is used in *democracy*. The demographic transition refers to a transition, or change, that is observed in human populations as countries become more developed.

✓ What factors are measured to determine if a demographic change is occurring?

Exponential Human Population Growth As countries became more developed, food supplies became more reliable and the global human population grew more rapidly. Better **sanitation** and medicine reduced death rates. The combination of lower death rates and high birthrates led to exponential growth. It took 123 years for the human population to double from 1 billion in 1804 to 2 billion in 1927. Then it took only 33 years to grow by another billion. The time it took to add another billion continued to decrease until 1999, when it began to slowly rise.

The Predictions of Malthus Exponential growth cannot continue forever. Two centuries ago, Thomas Malthus suggested that only war (competition), famine (limited resources), and disease could limit human population growth.

World Population Growth Slows The global human population grew exponentially until the growth rate reached a peak around 1959. Since the mid-1960s, the growth rate has been slowly decreasing. The total human population continues to grow, but at a slower rate.

Patterns of Human Population Growth

🔍 **KEY QUESTION** Why do population growth rates differ among countries?

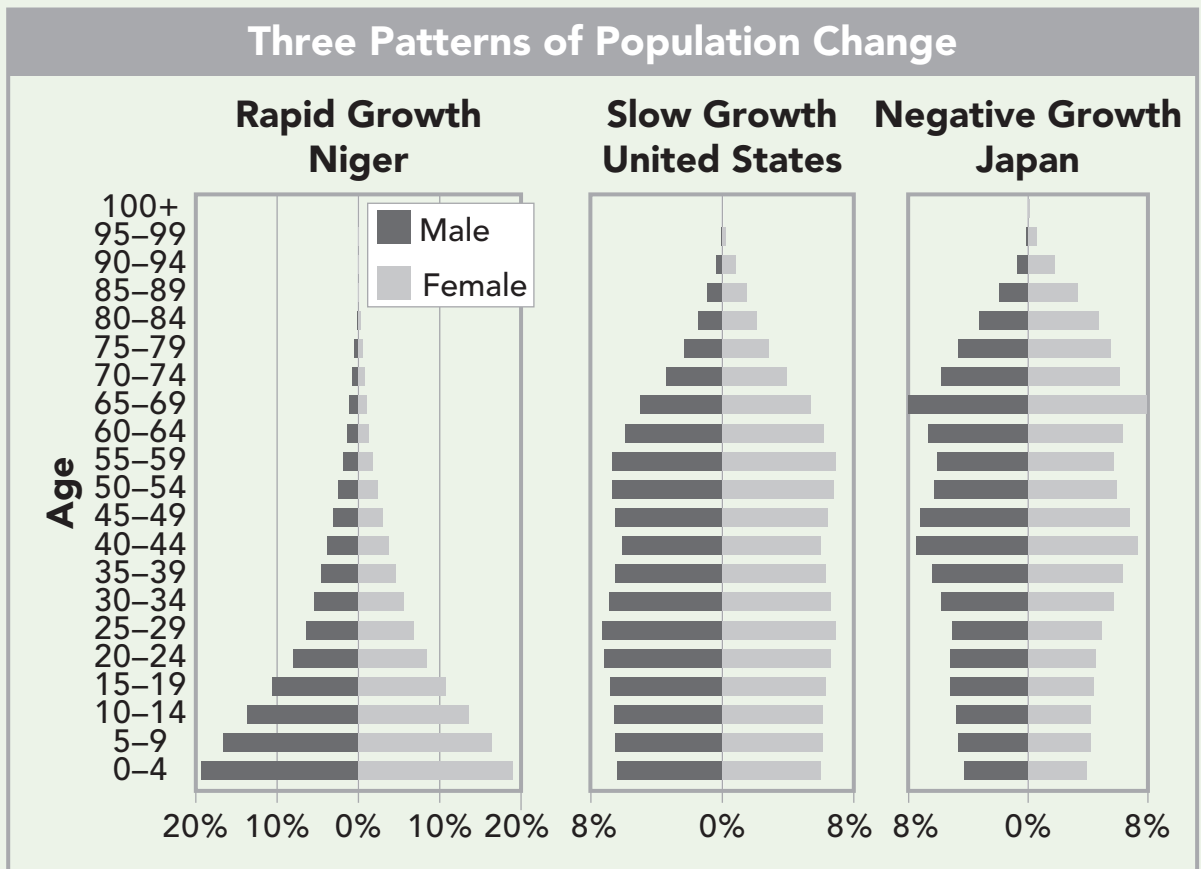
The scientific study of human populations is called **demography**. Demography examines characteristics of human populations and predicts how they will change. Birthrates, death rates, and the age structure of a population help predict why some countries have high growth rates while other countries’ populations increase more slowly.

The Demographic Transition Population growth has slowed dramatically over the past century in the United States, Japan, and much of Europe. Demographers hypothesize that these countries have completed the demographic transition. The **demographic transition** is a change from high birthrates and death rates to low birthrates and death rates. There are three stages to the demographic transition. In Stage 1, human birthrates and death rates are high. This describes most of human history. Next, advances in nutrition, sanitation, and medicine lead to lower death rates in Stage 2. In Stage 2, birthrates remain high and greatly exceed the death rate. The United States passed through Stage 2 between 1790 and 1910. As living standards rise, families have fewer children and the birthrate falls, which leads to Stage 3. Lastly, the falling birthrate leads to slower population growth. The demographic transition is complete when the birthrate is roughly equal to the death rate.

Age Structure and Population Growth The age structure of a population reveals how fast a population is growing. A greater percentage of young people indicate a growing population, and a greater percentage of older people indicate a shrinking population. The United States has nearly equal numbers of people in each age group. Demographers believe that many factors predict human population growth. The factors include age structure, the effects of deadly diseases, and malnutrition.

Visual Reading Tool: Determining Age Structure Patterns

Use the Patterns of Population Change Graph to help you answer the following questions.



Source: United Nations, World Population Prospects

1. What percentage of Japan's population is between the ages of 0-4 years?

2. Using the graph, explain why Niger's population is going through rapid growth.

3. What could cause Niger's rapid population growth?

5

Chapter Review

Review Vocabulary

Choose the letter of the best answer.

- the age and sex of members of a population
 - limiting factor
 - carrying capacity
 - age structure
 - demographic transition
- the number of individuals an environment can support
 - demography
 - carrying capacity
 - limiting factor
 - emigration

Match the vocabulary term to its definition.

- the number of individuals per unit area
 - limiting factor
 - population density
 - immigration
- movement of individuals into an area
- causes a decrease in population growth

Review Key Questions

Provide evidence and details to support your answers.

- A species is introduced into a new environment with plentiful resources and few predators. What will a graph of its population look like at first, and what is this pattern of growth called?
- Hunters kill all of the wolves in a region. The wolves mostly ate deer. Why might there be fewer deer a few years after the wolves are killed?
- How could a drought reduce the carrying capacity of an environment for a predator?
- How can you tell if a human population has passed through the demographic transition?