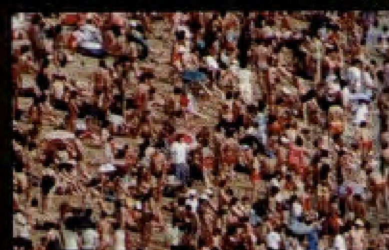
POPULATIONS

UNIT 3

CHAPTER 8
Understanding Populations



CHAPTER 9
The Human Population

CHAPTER 10
Biodiversity

This school of young striped catfish near the coast of Australia gathers into a huge, writhing ball to defend against predators. Forming a ball makes the fish look like one large organism, and the fish's stripes may make it hard for a predator to see individual fish.

Understanding Populations

CHAPTER 8

PRE-READING ACTIVITY

FOLDNOTES

Three-Panel Flip Chart

Before you read this chapter, create the **FoldNote** entitled "Three-Panel Flip Chart" described in the Reading and Study Skills section of the Appendix. Label the flaps of the chart with "Population," "Niche," and "Species Interaction." As you read the chapter, write information you learn about each category under the appropriate panel.

Orcas (also called killer whales) hunt sea lions. The interaction between these groups affects the number of individuals and the behavior of individuals in each group.

SECTION 1

How Populations Change in Size

Biologist Charles Darwin once calculated that a single pair of elephants could theoretically produce 19 million descendants within 750 years. Darwin made the point that the actual number of elephants is limited by their environment.

One way to study the relationship of elephants with their environment is at the level of populations. Such a study would include tracking the number of elephants in an area and observing the animals' interactions with their environment.

Objectives

- Describe the three main properties of a population.
- Describe exponential population growth.
- Describe how the reproductive behavior of individuals can affect the growth rate of their population.
- Explain how population sizes in nature are regulated.

Key Terms

population
density
dispersion
growth rate
reproductive potential
exponential growth
carrying capacity

What Is a Population?

A **population** is all the members of a species living in the same place at the same time. The bass in an Iowa lake make up one population. **Figure 1** shows other examples of populations. A population is a reproductive group because organisms usually breed with members of their own population. For example, daisies in an Ohio field will breed with each other and not with daisies in a Maryland population. The word *population* refers to the group in general and also to the size of the population—the number of individuals it contains.

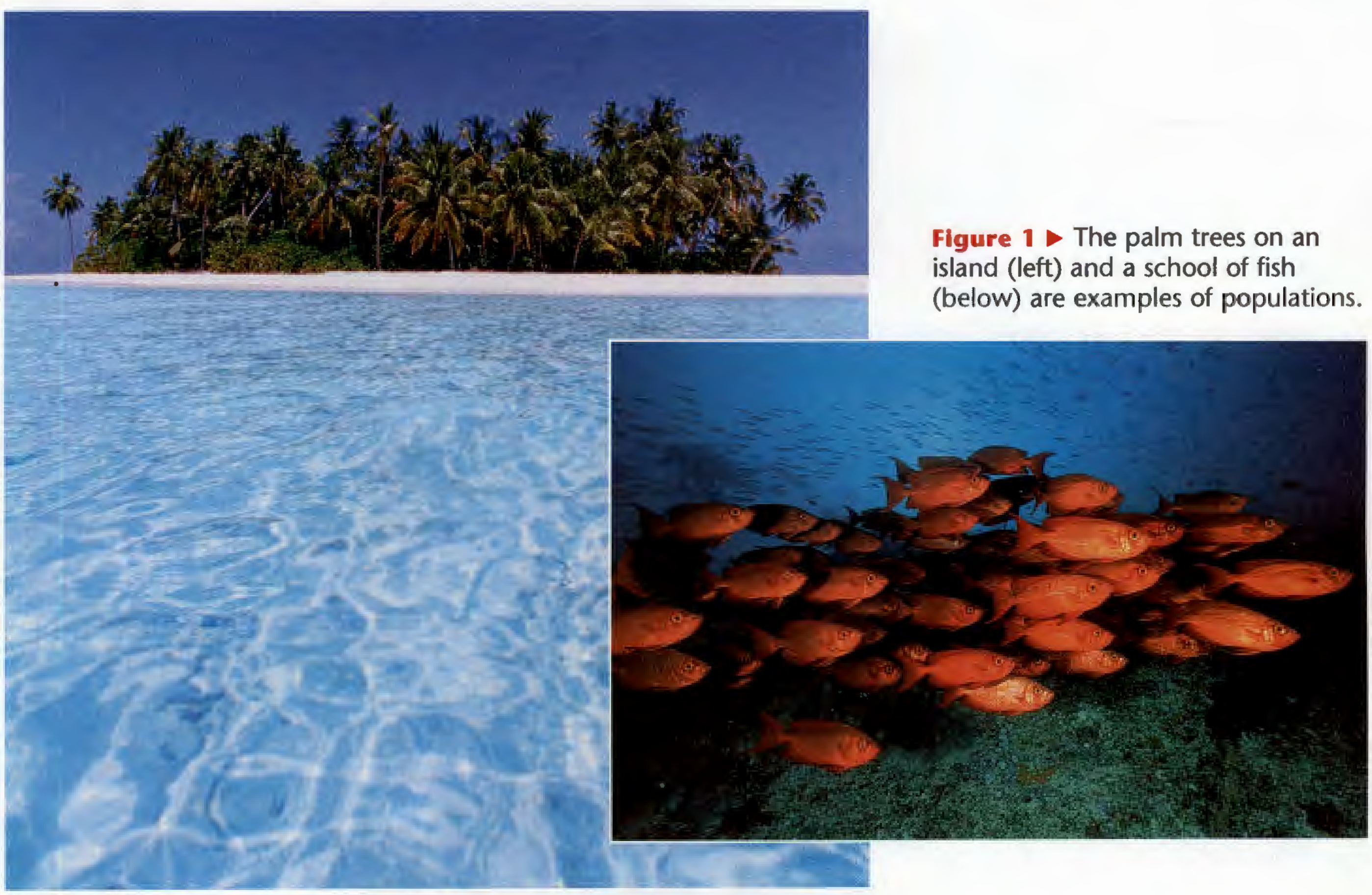


Figure 1 ▶ The palm trees on an island (left) and a school of fish (below) are examples of populations.

Figure 2 ▶ Populations may have very different sizes, densities, and dispersions. Flamingos (right) are usually found in huge, dense flocks, while most snakes (above) are solitary and dispersed randomly.

QuickLAB

Population Growth

Procedure

1. Model the change in size of a population by applying the equation at right.
2. Start with **100 g (3.5 oz) of dry beans.** Count out five beans to represent the starting population of a species.
3. Assume that each year 20 percent of the beans each have two offspring. Also assume that 20 percent of the beans die each year.
4. Calculate the number of beans to add or subtract for 1 y. Round your calculations to whole numbers. Add to or remove beans from your population as appropriate.
5. Continue modeling your population changes over the course of 10 y. Record each change.

Analysis

1. Make a graph of your data. Describe the changes in your population.

Properties of Populations

Populations may be described in terms of size, density, or dispersion, as shown in **Figure 2.** A population's **density** is the number of individuals per unit area or volume, such as the number of bass per cubic meter of water in a lake. A population's **dispersion** is the relative distribution or arrangement of its individuals within a given amount of space. A population's dispersion may be *even, clumped,* or *random.* Size, density, dispersion, and other properties can be used to describe populations and to predict changes within them.

How Does a Population Grow?

A population gains individuals with each new offspring or birth and loses them with each death. The resulting population change over time can be represented by the equation below. A change in the size of a population over a given period of time is that population's **growth rate.** The growth rate is the *birth rate* minus the *death rate.*

Change in population size = **Births** – **Deaths**

Over time, the growth rates of populations change because birth rates and death rates increase or decrease. Growth rates can be positive, negative, or zero. For a population's growth rate to be zero, the average number of births must equal the average number of deaths. A population would remain the same size if each pair of adults produced exactly two offspring, and each of those offspring survived to reproduce. If the adults in a population are not replaced by new births, the growth rate will be negative and the population will shrink.

How Fast Can a Population Grow?

A female sea turtle may lay 2,000 eggs in her lifetime in nests she digs in the sand. **Figure 3** shows newly hatched sea turtles leaving their nest for the ocean. If all of them survived, the turtle population would grow rapidly. But they do not all survive. Populations usually stay about the same size from year to year because various factors kill many individuals before they can reproduce. These factors control the sizes of populations. In the long run, the factors also determine how the population evolves.

Figure 3 ▶ Most organisms have a reproductive potential that far exceeds the number of their offspring that will survive. Very few of these baby sea turtles will survive long enough to breed.

Reproductive Potential A species' *biotic potential* is the fastest rate at which its populations can grow. This rate is limited by the maximum number of offspring that each member of the population can produce, which is called its reproductive potential. Some species have much higher reproductive potentials than others. Darwin calculated that it could take 750 years for a pair of elephants to produce 19 million descendants. In contrast, a bacterium can produce 19 million descendants in a few days or weeks.

Reproductive potential increases when individuals produce more offspring at a time, reproduce more often, and reproduce earlier in life. Reproducing earlier in life has the greatest effect on reproductive potential. Reproducing early shortens the *generation time,* the average time it takes a member of the population to reach the age when it reproduces.

Small organisms, such as bacteria and insects, have short generation times. These organisms can reproduce when they are only a few hours or a few days old. As a result, their populations can grow quickly. In contrast, large organisms, such as elephants and humans, become sexually mature after a number of years. The human generation time is about 20 years, so humans have a much lower reproductive potential than insects.

Exponential Growth Populations sometimes undergo exponential growth, which means they grow faster and faster. For example, if a pair of dogs gives birth to 6 puppies, there will be 6 dogs in one generation. If each pair of dogs in that generation has 6 puppies, there will be 18 dogs in the next generation. The following generation will contain 54 dogs, and so on. If the number of dogs is plotted versus time on a graph, the graph will have the shape shown in **Figure 4.** In exponential growth, a larger number of individuals is added to the population in each succeeding time period.

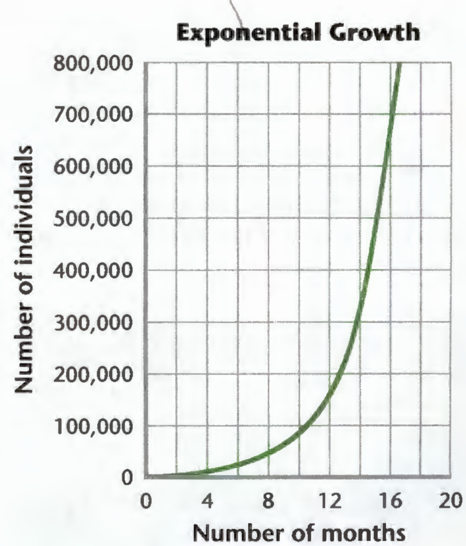


Figure 4 ▶ Population growth is graphed by plotting population size over a period of time. Exponential population growth will look like the curve shown here.

Exponential growth occurs in nature only when populations have plenty of food and space, and have no competition or predators. For example, populations of European dandelions and starlings imported into the United States underwent exponential growth. Similar population explosions occur when bacteria or molds grow on a new source of food.

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Carrying Capacity of Islands
Islands are good places to study carrying capacity because islands have clear boundaries. The Pribilof Islands near Alaska were the site of a well-studied population explosion and crash. In 1911, 25 reindeer were introduced on one of the islands. By 1938, the herd had grown to 2,000 animals. The reindeer ate mostly lichens, which grow back very slowly. By 1950, there were only 8 reindeer alive on the island.

What Limits Population Growth?

Because natural conditions are neither ideal nor constant, populations cannot grow forever and rarely grow at their reproductive potential. Eventually, resources are used up or the environment changes, and deaths increase or births decrease. Under the forces of natural selection in a given environment, only some members of any population will survive and reproduce. Thus, the properties of a population may change over time.

Carrying Capacity The blue line in **Figure 5** represents a population that seems to be limited to a particular size. This theoretical limit, shown by the dashed yellow line, is called *carrying capacity*. The **carrying capacity** of an ecosystem for a particular species is the maximum population that the ecosystem can support indefinitely. A population may increase beyond this number, but it cannot stay at this increased size. Because ecosystems change, carrying capacity is difficult to predict or calculate exactly. However, carrying capacity may be estimated by looking at average population sizes or by observing a population crash after a certain size has been exceeded.

The history of rabbits in Australia demonstrates both exponential growth and carrying capacity. Originally, there were no rabbits in the native ecosystems of Australia. When rabbits were introduced there in 1859, their numbers increased rapidly because they had plenty of vegetation to eat, no competition, and no predators. But eventually, disease and starvation caused the rabbit population to crash. Over time, the vegetation recovered, and the rabbit population increased again. The population continues to increase and decrease, but less dramatically.

Figure 5 ▶ An example of carrying capacity is shown by the dashed yellow line in the graph (right). This line seems to be a limit on the size of the example population (blue line). When rabbits were introduced into Australia (below), their population quickly exceeded the carrying capacity of the area.

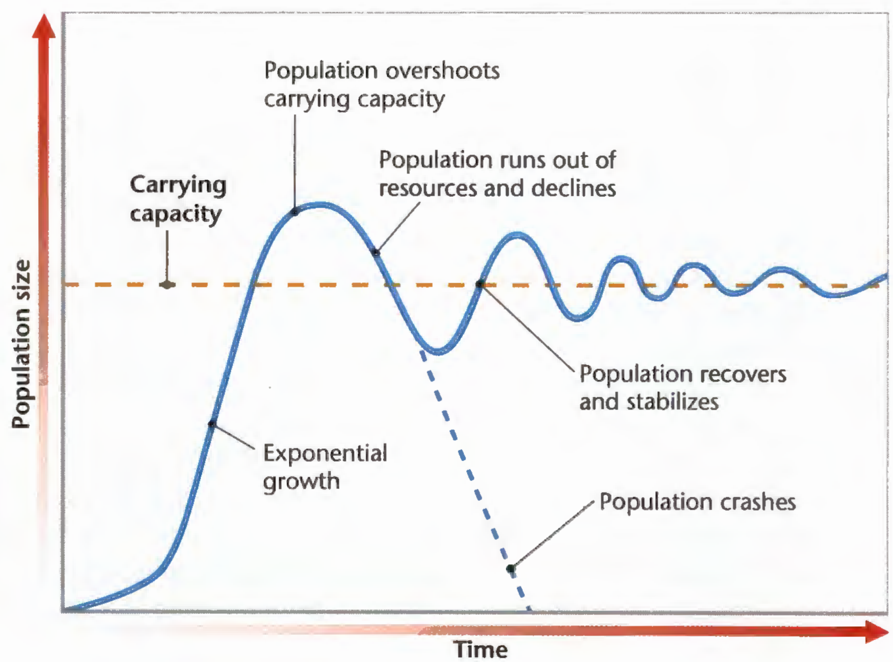

Figure 6 ▶ Members of a population often compete with each other. These plants (above) are growing over each other as they compete for light. These wolves (left) are competing for food and for social dominance.

Resource Limits A species reaches its carrying capacity when it consumes a particular natural resource at the same rate at which the ecosystem produces the resource. That natural resource is then called a *limiting resource* for the species in that area. For example, plant growth is limited by supplies of water, sunlight, and mineral nutrients. The supply of the most severely limited resources determines the carrying capacity of an environment for a particular species at a particular time.

Competition Within a Population The members of a population use the same resources in the same ways, so they will eventually compete with one another as the population approaches its carrying capacity. An example is the fate of mealworm larvae in a sack of flour. Adults of this type of beetle will find a sack of flour, lay their eggs in the sack, and leave. Most of the first larvae to hatch will have plenty of flour to eat and will grow to adulthood. However, the sack has a limited amount of food, and mealworms from eggs that were laid later may not have enough food to survive to adulthood.

Instead of competing directly for a limiting resource, members of a species may compete indirectly for social dominance or for a territory. A *territory* is an area defended by one or more individuals against other individuals. The territory is of value not only for the space but also for the shelter, food, or breeding sites it contains. Competition within a population is part of the pressure of natural selection. Many organisms expend a large amount of time and energy competing with members of the same species for mates, food, or homes for their families. Some examples of competition within species are shown in **Figure 6.**

MATHPRACTICE

Growth Rate A growth rate is a change in a population's size over a specific period of time.

$$\textit{growth rate} = \frac{\textit{change in population}}{\textit{time}}$$

Imagine a starting population of 100 individuals. If there were 10 births and 5 deaths in a given year, what was the population's growth rate for the year? In the next year, if there were 20 births and 10 deaths, what would the new growth rate be? If births increased by 10 and deaths increased by 5 for each of the next 5 years, how would you describe the growth of this population?

Figure 7 ▶ The way a disease spreads through a population is affected by the population's density. These pine trees have been infected by a disease carried by the southern pine beetle. This disease has spread rapidly through U.S. timber forests.

Connection to History

Density and Disease The black plague of 14th-century Europe was spread in a density-dependent pattern. About one-third of Europe's population died from the highly contagious disease. Most of the deaths occurred in the crowded towns of the time, and fewer deaths occurred in the countryside.

Figure 8 ▶ Weather events usually affect every individual in a similar way, so such events are considered density-independent regulation.

Two Types of Population Regulation

Population size can be limited in ways that may or may not depend on the density of the population. Causes of death in a population may be *density dependent* or *density independent*.

When a cause of death in a population is *density dependent*, deaths occur more quickly in a crowded population than in a sparse population. This type of regulation happens when individuals of a population are densely packed together, such as when a population is growing rapidly. Limited resources, predation, and disease result in higher rates of death in dense populations than in sparse populations. The pine trees in **Figure** 7 are infected with a disease that is spreading in a density-dependent pattern. Many of the same kind of pine tree are growing close to each other, so a disease-carrying beetle easily spreads the disease from one tree to another.

When a cause of death is *density independent*, a certain proportion of a population may die regardless of the population's density. This type of regulation affects all populations in a general or uniform way. Severe weather and natural disasters are often density-independent causes of death. The winter storm shown in **Figure** 8 froze crops and fruiting trees regardless of the density of plants in the area.

SECTION 1 Review

1. **Compare** two populations in terms of size, density, and dispersion. Choose any populations you know of.
2. **Describe** exponential population growth.
3. **Describe** three methods by which the reproductive behavior of individuals can affect the growth rate of a population.
4. **Explain** how population sizes in nature are regulated.

CRITICAL THINKING

5. **Making Predictions** How accurately do you think the size of a population can be predicted? What information might be needed to make this prediction?
6. **Compare and Contrast** Read the description of the populations of rabbits in Australia and reindeer in the Pribilof Islands. List the similarities and differences between these two histories. READING SKILLS

SECTION 2
How Species Interact with Each Other

What's the difference between lions in a zoo and lions in the wild? In the wild, lions are part of a community and a food web. In the African savanna, lions hunt zebras, fight with hyenas, and are fed upon by fleas and ticks. Interactions like these were part of the evolution of the lions that you see in zoos. Any species is best understood by looking at all of the relationships the species has within its native communities.

Objectives

- Explain the difference between niche and habitat.
- Give examples of parts of a niche.
- Describe the five major types of interactions between species.
- Explain the difference between parasitism and predation.
- Explain how symbiotic relationships may evolve.

Key Terms

niche
competition
predation
parasitism
mutualism
commensalism
symbiosis

An Organism's Niche

The unique role of a species within an ecosystem is its **niche** (NICH). A niche includes the species' physical home, the environmental factors necessary for the species' survival, and all of the species' interactions with other organisms. A niche is different from a habitat. An organism's *habitat* is a location. However, a niche is an organism's pattern of use of its habitat.

A niche can also be thought of as the functional role, or job, of a particular species in an ecosystem. For example, American bison occupied the niche of large grazing herbivores on American grasslands. Kangaroos occupy a similar niche on Australian grasslands. Herbivores often interact with carnivores, such as lions, if they both exist in the same habitat. Some parts of a lion's niche are shown in **Figure 9.**

Figure 9 ▶ Parts of a lion's niche are shown here. Can you think of other parts?

Types of Interactions Between Two Species			
Interaction	**Species A**	**Species B**	**Description**
Competition	harmed	harmed	Each species negatively affects the other.
Predation and parasitism	benefited	harmed	Species A feeds on species B.
Mutualism	benefited	benefited	Each species is helpful to the other.
Commensalism	benefited	unaffected	Species A benefits from species B, but B is unaffected.

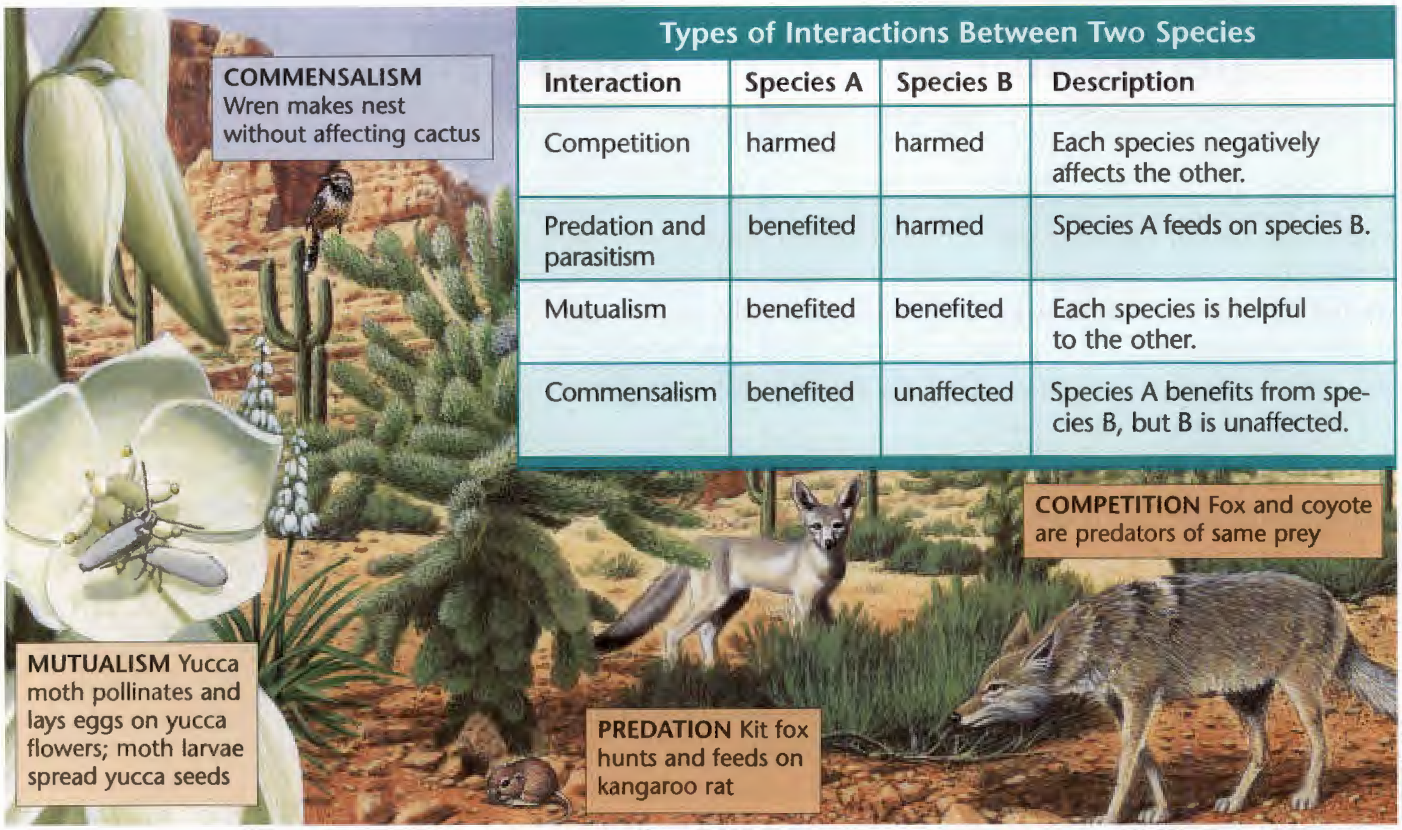

Figure 10 ▶ Species Interactions

Ways in Which Species Interact

Interactions between species are categorized at the level where one population interacts with another. The five major types of species interactions, summarized in **Figure 10**, are competition, predation, parasitism, mutualism, and commensalism. These categories are based on whether each species causes benefit or harm to the other species in a given relationship. Keep in mind that the benefit or harm is in terms of total effects over time. Also note that other types of interaction are possible. Many interactions between species are indirect, and some interactions do not fit a category clearly. Other types of interactions seem possible but are rarely found. Therefore, many interactions are neither categorized nor well studied.

Competition

For most organisms, competition is part of daily life. Seed-eating birds compete with each other for seed at a bird feeder, and weeds compete for space in a sidewalk crack. **Competition** is a relationship in which different individuals or populations attempt to use the same limited resource. Each individual has less access to the resource and so is harmed by the competition.

Competition can occur both within and between species. We have learned that members of the same species must compete with each other because they require the same resources—they occupy the same niche. When members of different species compete, we say that their niches *overlap*, which means that each species uses some of the same resources in a habitat.

FIELD ACTIVITY

Observing Competition You can study competition between bird species at home or at school. Build a bird feeder using a plastic milk jug, a metal pie pan, or some other inexpensive material. Fill the feeder with unsalted bread crumbs, sunflower seeds, or commercial birdseed.

Observe the birds that visit the feeder. Sit quietly in the same spot, and make observations at the same time each day for several days in a row.

In your ***EcoLog***, keep a record that includes data about the kinds of birds that use the feeder, the kinds of seeds that the birds prefer, the factors that affect how much the birds eat, and the kinds of birds that are better competitors for the birdseed.

Indirect Competition Species can compete even if they never come into direct contact with each other. Suppose that one insect species feeds on a certain plant during the day and that another species feeds on the same plant during the night. Because they use the same food source, the two species are indirect competitors. Similarly, two plant species that flower at the same time may compete for the same pollinators even if the plants do not compete in any other way. Humans rarely interact with the insects that eat our food crops, but those insects are still competing with us for food.

Adaptations to Competition When two species with similar niches are placed together in the same ecosystem, we might expect one species to be more successful than the other species. The better-adapted species would be able to use more of the niche. But in the course of evolution, adaptations that decrease competition will also be advantageous for species whose niches overlap.

One way competition can be reduced between species is by dividing up the niche in time or space. *Niche restriction* is when each species uses less of the niche than they are capable of using. Niche restriction is observed in closely related species that use the same resources within a habitat. For example, two similar barnacle species compete for space in the intertidal zone of rocky shorelines. One of the species, *Chthamalus stellatus,* is found only in the upper level of the zone when the other species is present. But when the other species is removed from the area, *C. stellatus* is found at deeper levels, as shown in **Figure 11.** In the presence of competition, the actual niche used by a species may be smaller than the potential niche. Ecologists have observed various other ways of dividing up a niche among groups of similar species.

Ecofact

A Wide Niche Coyotes live in a wide range of habitats and are willing to get close to human settlements. Coyotes are also known to eat a wide variety of animals and plants, including food that humans throw away. Thus, coyotes have a broad and varied niche. Coyotes take advantage of those parts of their niche that are easiest to use and that present less competition.

Graphic Organizer **Spider Map** Create the **Graphic Organizer** entitled "Spider Map" described in the Appendix. Label the circle "Species Interactions." Create a leg for each type of species interaction. Then, fill in the map with details about each type of species interaction.

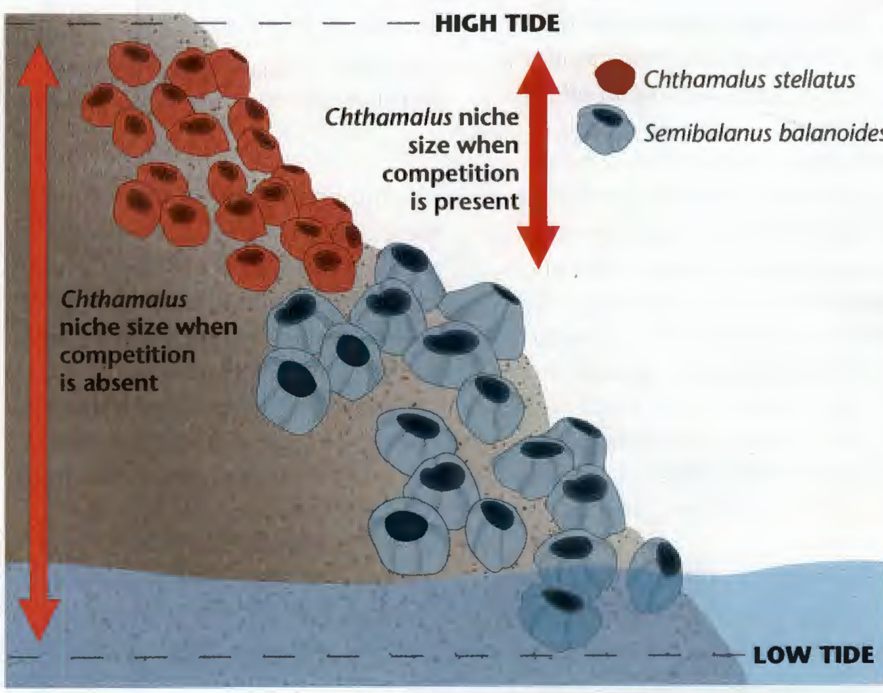

Figure 11 ▶ The barnacle species *Chthamalus stellatus* uses less of its potential niche when competing for space with a similar barnacle species, *Semibalanus balanoides.*

Figure 12 ▶ This predatory bird had to outrun its prey. Many organisms are adapted to avoid predation.

Predation

An organism that feeds on another organism is called a *predator*, and the organism that is fed upon is the *prey*. This kind of interaction is called **predation.** Examples of predation include snakes eating mice, bats eating insects, or whales consuming krill. **Figure 12** shows a predatory bird with its captured prey.

Predation is not as simple to understand as it seems. We may think of predators as meat-eating animals, but there can be less obvious kinds of predators. In complex food webs, a predator may also be the prey of another species. Most organisms have evolved some mechanisms to avoid or defend against predators.

Some predators eat only specific types of prey. For example, the Canadian lynx feeds mostly on snowshoe hares during the winter. In this kind of

CASE STUDY

Predator-Prey Adaptations

Most organisms are vulnerable to predation, so there is strong selective pressure for adaptations that serve as defenses against predators.

Many animals are *camouflaged*—disguised so that they are hard to see even when they are in view. Visual camouflage is very obvious to us, because vision is the dominant sense in humans. Many predators also have keen vision. An animal's camouflage usually disguises its recognizable features. The eyes are the most recognizable part of the animal, and hundreds of species have black stripes across their eyes for disguise. Dark bands of color, such as those on many snakes, may also break up the apparent bulk of the animal's body.

Some predators do not chase their prey but wait for the prey to come near enough to be caught. Praying mantises and frogs are examples of these types of predators. Such predators are usually camouflaged so that the prey does not notice them waiting to attack.

Animals, and more often plants, may contain toxic chemicals that harm or deter predators. Many animals that have chemical defenses have a striking coloration. This *warning coloration* alerts potential predators to stay away and protects the prey species from damage. Patterns with black stripes and red, orange, or yellow are common in many species of bees, wasps, skunks, snakes, and poisonous frogs.

Warning coloration works well against predators that can learn and that have good vision.

▶ Patterns of black and red, orange, or yellow are common warning signs.

During the course of evolution, members of several well-protected species have come to resemble each other. For example, both bees and wasps often have black and yellow stripes. This is an example of *mimicry* of one species by another. The advantage of mimicry is that the more individual organisms that have the same pattern, the less chance any one individual has of being killed. Also, predators learn to avoid all animals that have similar warning patterns.

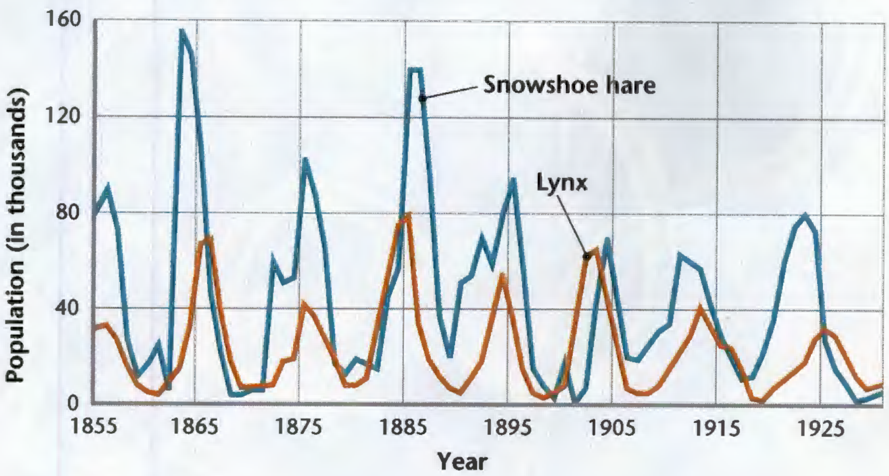

Figure 13 ▶ Populations of predators depend on populations of prey, so changes in one of these populations may be linked to changes in the other. This graph shows population estimates over time for Canadian lynx and their favorite food, snowshoe hares.

close relationship, the sizes of each population tend to increase and decrease in linked patterns, as shown in **Figure 13.** However, many predators will feed on whichever type of prey is easiest to capture.

▶ Both predators and prey may exhibit adaptations such as camouflage or mimicry. The spider that looks like an ant (left) is a predator of insects. The protective quills of this porcupine (right) are a simple but effective way to repel predators.

Occasionally, a harmless species is a mimic of a species that has chemical protection. You have probably tried to get away from insects that you thought were wasps or bees. In fact, some of them were probably flies. Several species of harmless insects have evolved to mimic wasps and bees. On the other hand, sometimes a predator may look like another, less threatening species. Some species of spiders may be mistaken for ants or other types of insects.

A simple defense against predation is some type of *protective covering.* The quills of a porcupine, the spines of a cactus, and the shell of a turtle are all examples of protective covering.

CRITICAL THINKING

1. Making Comparisons For each of these types of adaptations, give an additional example that you have seen or heard of.

2. Determining Cause and Effect Write a paragraph to explain how one of these adaptations might have evolved. WRITING SKILLS

Figure 14 ▶ Parasites such as ticks (left) and intestinal worms (right) could be harmful to you. You probably try to avoid these parasites, almost as if they were predators. In what ways are parasites like predators?

Parasitism

An organism that lives in or on another organism and feeds on the other organism is a *parasite*. The organism the parasite takes its nourishment from is known as the *host*. The relationship between the parasite and its host is called **parasitism.** Examples of parasites are ticks, fleas, tapeworms, heartworms, bloodsucking leeches, and mistletoe.

The photos of parasites in **Figure 14** may make you feel uneasy, because parasites are somewhat like predators. The differences between a parasite and a predator are that a parasite spends some of its life in or on the host, and that parasites do not usually kill their hosts. In fact, the parasite has an evolutionary advantage if it allows its host to live longer. However, the host is often weakened or exposed to disease by the parasite.

Figure 15 ▶ These acacia trees in Central America have a mutualistic relationship with these ants. The trees provide food and shelter to the ants, and the ants defend the tree.

Mutualism

Many species depend on another species for survival. In some cases, neither organism can survive alone. A close relationship between two species in which each species provides a benefit to the other is called **mutualism.** Certain species of bacteria in your intestines form a mutualistic relationship with you. These bacteria help break down food that you could not otherwise digest or produce vitamins that your body cannot make. In return, you give the bacteria a warm, food-rich habitat.

Another case of mutualism happens in the ant acacia trees of Central America, shown in **Figure 15.** Most acacia trees have spines that protect them against plant-eating animals, but the ant acacias have an additional protection—an ant species that lives only on these trees. The trees provide these ants shelter within hollow thorns as well as food sources in sugary nectar glands and nutrient-rich leaf tips. In turn, the ants defend the tree against herbivores and many other threats.

Figure 16 ▶ Remoras have a commensal relationship with sharks. Remoras attach themselves to sharks in order to eat scraps from the sharks' meals, or to hitch a ride elsewhere. The remoras cause neither benefit nor harm to the sharks. There are many examples of freeloaders and scavengers in nature.

Commensalism

A relationship in which one species benefits and the other species is neither harmed nor helped is called **commensalism.** An example is the relationship between sharks and a type of fish called remoras, which are shown in **Figure 16.** Remoras attach themselves to sharks and feed on scraps of food left over from the shark's meals. Another example of commensalism is when birds nest in trees, but only if the birds do not cause any harm to the tree. Even a seemingly harmless activity might have an effect on another species.

Symbiosis and Coevolution

A relationship in which two organisms live in close association is called **symbiosis.** Many types of species interactions are considered symbiotic in some cases. Symbiosis is most often used to describe a relationship in which at least one species benefits.

Over time, species in close relationships may *coevolve*. These species may evolve adaptations that reduce the harm or improve the benefit of the relationship. Recall that harm and benefit are measured in total effects over time. For example, coevolution can be seen in the relationships of flowering plants and their pollinators. Many types of flowers seem to match the feeding habits of certain species of insects or other animals that spread pollen.

Connection to Biology

An Ecosystem in Your Body
Our health is affected by our relationships with microorganisms in our digestive system, skin, blood, and other parts of our body. For example, live-culture yogurt is considered a healthy food because the kinds of bacteria it contains are beneficial to us. The bacteria assist our digestion of dairy products and also compete with other microorganisms, such as yeast, that might cause infections.

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SECTION 2 Review

1. **List** as many parts as you can of the niche of an organism of your choice.
2. **Give examples** of species that have the same habitat but not the same niche that a lion has.
3. **Describe** the five types of species interactions.

CRITICAL THINKING

4. **Making Comparisons** Read the definition of parasites and predators, and then explain how parasites differ from predators. READING SKILLS
5. **Analyzing Relationships** Choose an example of mutualism, and then describe the long process by which the relationship could have developed.

CHAPTER 8

Highlights

1 How Populations Change in Size

Key Terms

population, 197
density, 198
dispersion, 198
growth rate, 198
reproductive potential, 199
exponential growth, 199
carrying capacity, 200

Main Ideas

- Each population has specific properties, including size, density, and pattern of dispersion.
- Each population has a characteristic reproductive potential. This is the fastest possible growth rate of the population.
- When a population has few limits to its growth, it may have an exponential growth rate. Usually, population growth is limited by factors such as disease and competition.
- Carrying capacity is the maximum population a habitat can support over time.
- A population that grows rapidly may be subject to density-dependent regulation.

2 How Species Interact with Each Other

Key Terms

niche, 203
competition, 204
predation, 206
parasitism, 208
mutualism, 208
commensalism, 209
symbiosis, 209

Main Ideas

- The niche of an organism is its pattern of use of its habitat and its interactions with other organisms.
- Interactions between species are categorized based on the relative benefit or harm that one species causes the other. The categories are competition, predation, parasitism, mutualism, and commensalism.
- Competition between species occurs when their niches overlap. The competition may be direct or indirect.
- Pairs of species that have close relationships often evolve adaptations that either increase the benefit of or reduce the harm from the relationship.

CHAPTER 8

Review

Using Key Terms

Use each of the following terms in a separate sentence.

1. *reproductive potential*
2. *carrying capacity*
3. *competition*
4. *symbiosis*

For each pair of terms, explain how the meanings of the terms differ.

5. *niche* and *habitat*
6. *predator* and *prey*
7. *predation* and *parasitism*
8. *mutualism* and *commensalism*

STUDY TIP

Review with a Partner To review the main ideas of the text, try summarizing with a partner. Take turns reading a passage, and then try to summarize aloud what you have read. Try not to look back at the text. Then, discuss and review the text with your partner to check your understanding.

Understanding Key Ideas

9. In which of the following pairs do both organisms belong to the same population?
   a. a rose and a carnation
   b. a zebra and a horse
   c. two residents of New York City
   d. two similar species of monkeys

10. A population of some species is most likely to grow exponentially
   a. if the species is already very common in the area.
   b. when the species moves into a new area of suitable habitat.
   c. when it uses the same habitat as a similar species.
   d. if the population size is already large.

11. A population will most likely deplete the resources of its environment if the population
   a. grows beyond carrying capacity.
   b. must share resources with many other species.
   c. moves frequently from one habitat to another.
   d. has a low reproductive potential.

12. The growth rate of a population of geese will probably increase within a year if
   a. more birds die than are hatched.
   b. several females begin laying eggs at younger ages than their mothers did.
   c. most females lay two eggs instead of three during a nesting season.
   d. some birds get lost during migration.

13. Which of the following is an example of competition between species?
   a. two species of insects feeding on the same rare plant
   b. a bobcat hunting a mouse
   c. a lichen, which is an alga and a fungus living as a single organism
   d. a tick living on a dog

14. Which of the following statements about parasitism is true?
   a. The presence of a parasite does not affect the host.
   b. Parasitism is a cooperative relationship between two species.
   c. Parasites always kill their hosts.
   d. Parasitism is similar to predation.

15. Ants and acacia trees have a mutualistic relationship because
   a. they are both adapted to a humid climate.
   b. they are part of the same ecosystem.
   c. they benefit each other.
   d. the ants eat parts of the acacia tree.

16. Which of the following is an example of coevolution?
   a. flowers that can be pollinated by only one species of insect
   b. rabbits that invade a new habitat
   c. wolves that compete with each other for territory
   d. bacteria that suddenly mutate in a lab

CHAPTER 8
Review

Short Answer

17. A tapeworm lives in the intestines of a cow and feeds by absorbing food that the cow is digesting. What kind of relationship is this? Explain your answer.

18. Explain how two species can compete for the same resource even if they never come in contact with each other.

19. Snail kites are predatory birds that feed only on snails. The kites use their hooked, needle-like beaks to pull snails from their shells. Explain how these specialized beaks might have evolved in these birds.

20. What would happen to the population of snail kites mentioned in question 19 if the snails' habitat was destroyed? Explain your answer.

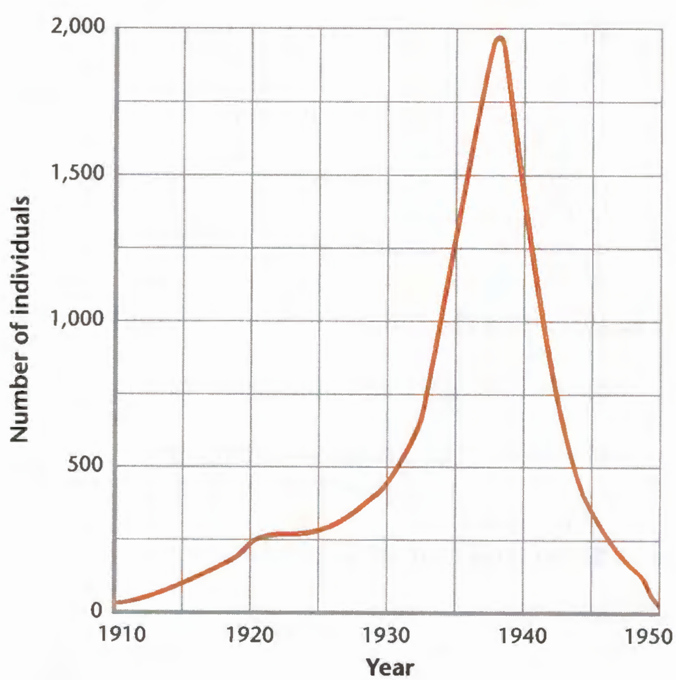
Interpreting Graphics

The graph below shows the population of some reindeer that were introduced to an Alaskan island in 1910. Use the graph to answer questions 21–23.

21. Describe this population's changes over time.

22. What might have happened in 1937?

23. How would you estimate this island's carrying capacity for reindeer? Explain your answer.



Concept Mapping

24. Use the following terms to create a concept map: *symbiosis, predation, predator, prey, parasitism, parasite, host, mutualism,* and *commensalism.*

Critical Thinking

25. Analyzing Relationships Read the explanations of competition and predation. If one species becomes extinct, and then soon after, another species becomes extinct, was their relationship most likely competition or predation? Explain your answer. READING SKILLS

26. Evaluating Hypotheses Scientists do not all agree on the specific carrying capacity of Earth for humans. Why might this carrying capacity be difficult to determine?

27. Evaluating Conclusions A scientist finds no evidence that any of the species in a particular community are competing and concludes that competition never played a role in the development of this community. Could this conclusion be valid? Write a paragraph to explain your answer. WRITING SKILLS

Cross-Disciplinary Connection

28. Health Viruses are the cause of many infectious diseases, such as common colds, flu, and chickenpox. Viruses can be passed from one person to another in many different ways. Under what conditions do you think viral diseases will spread most rapidly between humans? What can be done to slow the spread of these viruses?

Portfolio Project

29. Create a Niche Map Create a visual representation of the niche of an organism of your choice. Research the organism's habitat, behaviors, and interactions with other species. If possible, observe the organism (without disturbing it) for a day or more. Create a piece of art to show all of the interactions that this organism has with its environment.

MATH SKILLS

Use the equation below to answer questions 30–31.

Change in population size = **Births** − **Deaths**

30. **Extending an Equation** The equation gives the change in a population over a given amount of time (for example, an increase of 100 individuals in one year). Use the two parts on the right side of the equation to write an inequality that would be true if the population were increasing. Rewrite the inequality for a decreasing population.

31. **Analyzing an Equation** Suppose you are studying the small town of Hill City, which had a population of 100 people in the first year of your study. One year later, 10 people have died, and only 9 mothers have given birth. Yet the population has increased to 101. How could this increase happen?

WRITING SKILLS

32. **Communicating Main Ideas** Why do population sizes not grow indefinitely?

33. **Creative Writing** Write a science fiction story about life without competition.

34. **Writing from Research** Find information in encyclopedias or natural history references about different kinds of mutualism. Summarize the similarities and differences between the various relationships. Focus on the ways in which each species benefits from the other species.

STANDARDIZED TEST PREP

For extra practice with questions formatted to represent the standardized test you may be asked to take at the end of your school year, turn to the sample test for this chapter in the Appendix.

READING SKILLS

Read the passage below, and then answer the questions that follow.

Excerpt from Charles Darwin, On the Origin of Species, *1859.*

I should premise that I use the term struggle for existence in a large and metaphorical sense, including dependence of one being on another, and including (which is more important) not only the life of the individual, but success in leaving progeny. Two canine animals in a time of dearth, may truly be said to struggle with each other which shall get food and live. But a plant on the edge of the desert is said to struggle for life against the drought, though more properly it should be said to be dependent on the moisture. A plant which annually produces a thousand seeds, of which on average only one comes to maturity, may more truly be said to struggle with the plants of the same and other kinds which already clothe the ground . . . In these several senses, which pass into each other, I use for convenience sake the general term of struggle for existence.

1. Which of the following statements best describes the author's main purpose in this passage?
   - **a.** to describe the process of reproduction
   - **b.** to persuade the reader that all animals struggle for existence
   - **c.** to explain the meaning of the author's use of the phrase *struggle for existence*
   - **d.** to argue that life in the desert depends on moisture

2. Which of the following statements most closely matches what the author means by the phrase *struggle for existence*?
   - **a.** whenever plants or animals interact in nature
   - **b.** whenever plants or animals compete to survive and to produce offspring
   - **c.** when plants produce many more seeds than are likely to grow
   - **d.** when animals compete for food during difficult times

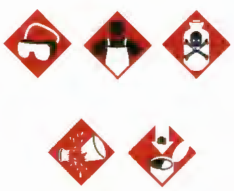
CHAPTER 8 Skills Practice Lab: OBSERVATION

Objectives

- **USING SCIENTIFIC METHODS** **Observe, record, and graph** the growth and decline of a population of yeast cells in an experimental environment.
- **USING SCIENTIFIC METHODS** **Predict** the carrying capacity of an environment for a population.
- **Infer** the limiting resource of an environment.

Materials

compound microscope
methylene blue solution, 1%
micrometer, stage type or eyepiece disc for microscope
microscope slide, with coverslip (5)
pipet, 1 mL (5)
test tube (5)
yeast culture, in an Erlenmeyer flask (5)



▶ **Budding Yeast** This live, budding yeast cell is magnified 3,025 times by a scanning electron microscope.

Studying Population Growth

You have learned that a population will keep growing until limiting factors slow or stop this growth. How do you know when a population has reached its carrying capacity? In this lab, you will observe the changes in a population of yeast cells. The cells will grow in a container and have limited food over several days.

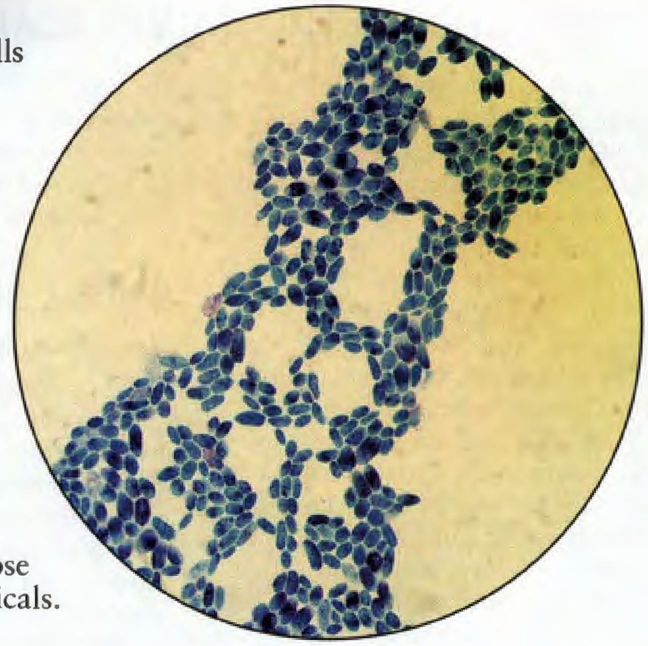
Procedure

1. Your teacher will prepare several cultures of household baker's yeast (fungi of the genus *Saccharomyces*) in flasks. Each yeast culture will have grown for a different period of time in the same type of environment. Each flask will have been prepared with 500mL lukewarm water, 1 g of active dry yeast, and 20 g of sugar. The sugar is the only food source for the yeast.
2. Make two data tables like the one shown below. One table will contain your observations of living yeast cells, and the other table will be for observations of dead yeast cells.

Cell Counts						
Time (h)	1	2	3	4	Average	Class Average
0						
12						
24						
36						
48						

3. Take a sample of yeast culture from the first flask (Time 0). Swirl the flask gently to mix the yeast cells evenly, and then immediately use the pipet to transfer 1 mL of yeast culture to a test tube. Add two drops of methylene blue solution to the test tube. The methylene blue will stain the dead yeast cells a deep blue but will not stain the living cells.
4. Make a wet mount by placing a small drop of your mixture of yeast and methylene blue on a microscope slide. Cover the slide with a coverslip.
5. Observe the mounted slide under the low power of a compound microscope. (Note: Adjust the light so that you can clearly see both stained and unstained cells.) After focusing, switch the microscope to high power (400× or 1,000×).
6. Count the live (unstained) yeast cells and the dead (stained) cells that you see through the microscope. Use the micrometer ruler, or ask your teacher for the best counting method. Record the numbers of live cells and dead cells in your data tables.

7. Move the microscope slide slightly, and then make another count of the number of living and dead cells that you can see. Repeat this step until you have made four counts of the cells on the slide.
8. Calculate and record the average number of live cells per observation. Record this number in your data table. Do the same calculation for the dead cells.
9. Predict how many live and dead cells you expect to count in the samples from the other flasks. Record your prediction.
10. Repeat steps 3–8 for each of the flasks to obtain data that represents the growth of a population over a 48-hour period.
11. Clean up your work area, and store all lab equipment appropriately. Ask your teacher how to dispose of the yeast samples and any extra or spilled chemicals.



▶ **Stained Yeast Cells** These yeast cells have been stained with methylene blue and magnified 1,000 times with a microscope. Methylene blue gives a deep blue color to dead yeast cells but not to live yeast cells.

Analysis

1. **Analyzing Data** Share your data with the rest of the class. Calculate and record the class averages for each set of observations.
2. **Constructing Graphs** Graph the changes in the average numbers of live yeast cells and dead yeast cells over time. Plot the average number of cells per observation on the y-axis and the time (in hours from start of culture) on the x-axis.
3. **Describing Events** Describe the general population changes you observed in the yeast cultures over time.

Conclusions

4. **Evaluating Methods** Why were several counts taken and then averaged for each time period?
5. **Evaluating Results** Were your predictions of the yeast cell counts close to the actual average counts? How close were your predictions relative to the variation among all the samples?
6. **Applying Conclusions** Did the yeast cell populations appear to reach a certain carrying capacity? What was the limiting resource in the experimental environment of the flasks?

Extension

1. **Designing Experiments** Form a hypothesis about another factor that might limit the yeast's population growth, and explain how you would test this hypothesis.

>POINTS >of view

WHERE SHOULD THE WOLVES ROAM?

The gray wolf was exterminated from much of the northwestern United States by the 1920s. Ranchers and federal agents killed the animal to protect livestock. The Rocky Mountain gray wolf was listed as an endangered species in 1973. Then in the 1980s, the U.S. Fish and Wildlife Service began a plan to restore wolf populations in the United States. The agency decided to reintroduce wolves into certain areas. Biologists looked for areas where wolves could have large habitats and enough food. Three areas were chosen, as shown in the figure below.

Between 1995 and 1996, 64 wolves were released in Yellowstone National Park and 34 wolves were released in central Idaho. The original goal was to have breeding populations of at least 100 wolves in each location by 2002. This goal has now become reality.

The wolf reintroduction efforts remain controversial. Some people would prefer that the wolves become extinct. On the other side, some people think that the government has not done enough to protect wolf populations. Read the following points of view, and then analyze the issue for yourself.

Wolves Should Not Be Reintroduced

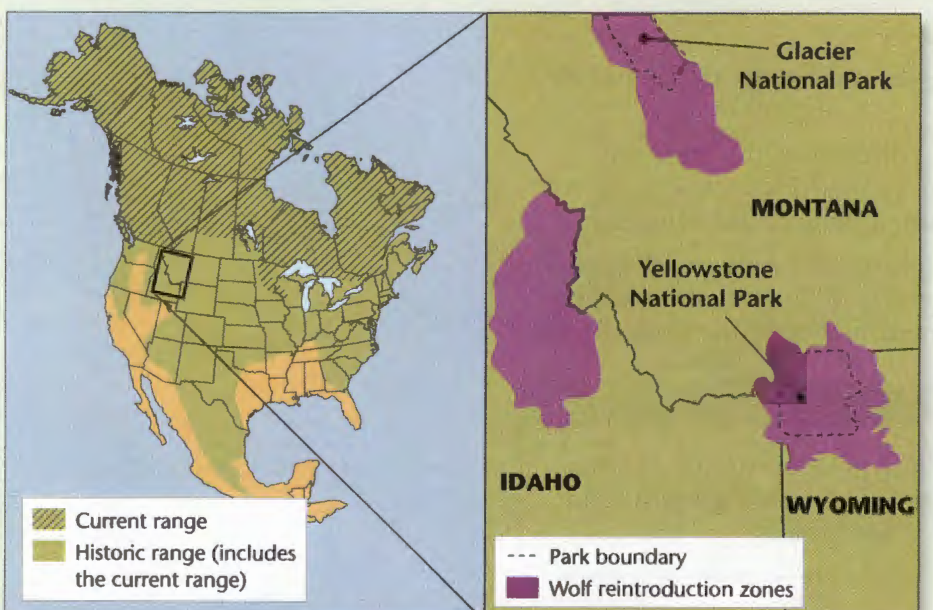
Some opponents of the reintroduction plan argue that wolves are not truly endangered. Biologists estimate that hundreds of wolves live in Minnesota, and thousands live in Alaska and Canada. Because there are large numbers of wolves in the wild, some people feel that wolves should not receive special treatment as endangered species.

Many hunters also oppose the plan to reintroduce wolves. Both hunters and wolves hunt for large game animals such as deer, elk, or moose. Hunters believe the wolves might create too much competition for the game animals. Some studies suggest that populations of game animals will decrease if hunted by both humans and wolves.

▶ **A wild wolf** is a now rare sight in most of the United States. Efforts to reintroduce and protect wolf populations are controversial.

Hunters point out that hunting is an important part of the economies of the western states. Also, licensed hunting has become part of the way large parks and wildlife preserves are managed. Hunting is sometimes allowed by park and game managers to control wildlife populations. Hunting fees also help fund wildlife management efforts, such as habitat improvement and biological studies.

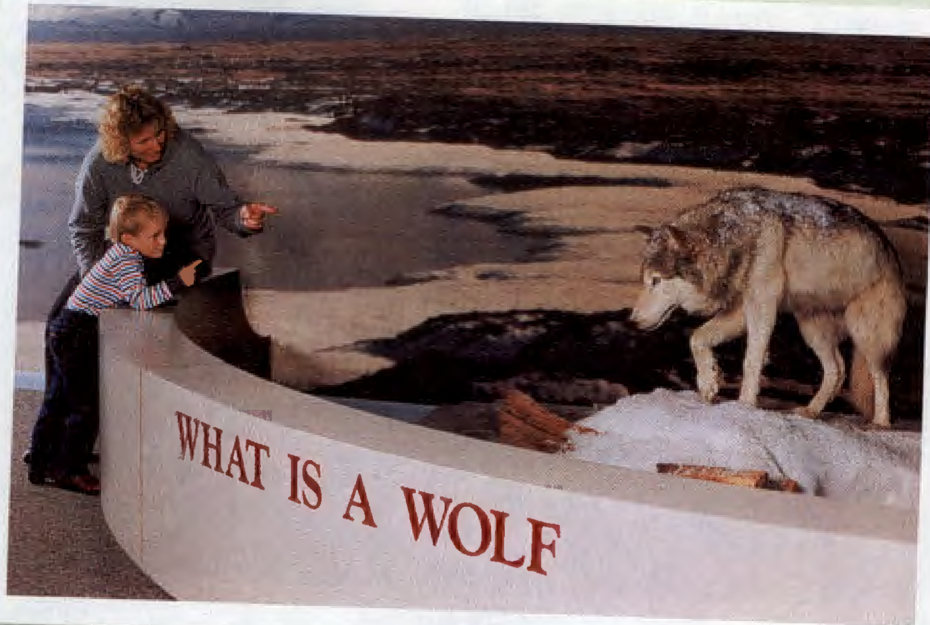
Ranchers are among the people who most strongly oppose wolf reintroduction. Ranchers worry that wolves will kill their livestock. Ranchers argue that they cannot afford to lose their livestock. Even though there is a program to pay ranchers for lost livestock, the program will last



▶ **The breeding range of the gray wolf** (far left) has been lost in most of the United States. The U.S. government has reintroduced wolves into parts of Montana, Wyoming, and Idaho (left).

only as long as wolves are classified as an endangered species. When there are many wolves again in the target areas, the wolf will no longer have endangered status. Ranchers point out that the payment program will disappear when it would be needed most.

Other groups that oppose wolf reintroduction include groups that use public lands for activities such as logging or mining. These groups worry that protection for the wolves may lead to the prevention of other uses of land in the target areas.



▶ **The International Wolf Center in Minnesota** tries to educate the public about wolves. The center's "Wolves and Humans" exhibit is shown here.

Wolves Should Be Reintroduced

A basic argument in favor of wolf reintroduction is that the federal government must uphold the law by trying to restore wolf populations in the United States. But supporters of wild wolves give other reasons too.

Many environmentalists and scientists believe that the reintroduction plan could restore a balance to the Yellowstone ecosystem. Predation by wolves would keep the herds of elk, moose, and deer from growing too dense and overgrazing the land.

The argument that wolves help control wild herds is like the argument in favor of hunting. Some wolf supporters even say that licensed hunting of wolves should be allowed. In this way, hunters might support the reintroduction plans, and populations of both wolves and game animals could be managed.

In response to ranchers' concerns that wolves will attack their livestock, biologists say that this is not likely to be a problem. There is evidence that most wolves prefer to hunt wild animals rather than domestic animals. Wolves rarely attack livestock when large herds of wild game are nearby. In fact, from 1995 to 1997, fewer than five wolf attacks on livestock were reported in the United States.

Still, some supporters of reintroduction have tried to address the concerns of ranchers. One group raised money to pay ranchers for livestock killed by wolves. Other groups conduct studies and educational programs or talk with local landowners. Most wolf supporters are trying to create reintroduction plans that will work for both humans and wolves.

In response to fears that the wolves pose a danger to humans, supporters say this is also unlikely. There have been no verified attacks on humans by healthy wolves in North America. Wolf experts insist that wolves are shy animals that prefer to stay away from people.

Most wolf supporters admit that there are only a few places where wolves may live without causing problems. Supporters of the plan believe that the target areas are places where wolves can carry out a natural role without causing problems for humans.

What Do You Think?

Like many plans to protect endangered species, the plan to reintroduce wolves causes some people to weigh their own interests against the needs of a single species. Do you feel that the decision is a simple one? Can you think of other ways to look at this issue? Explain your answers.