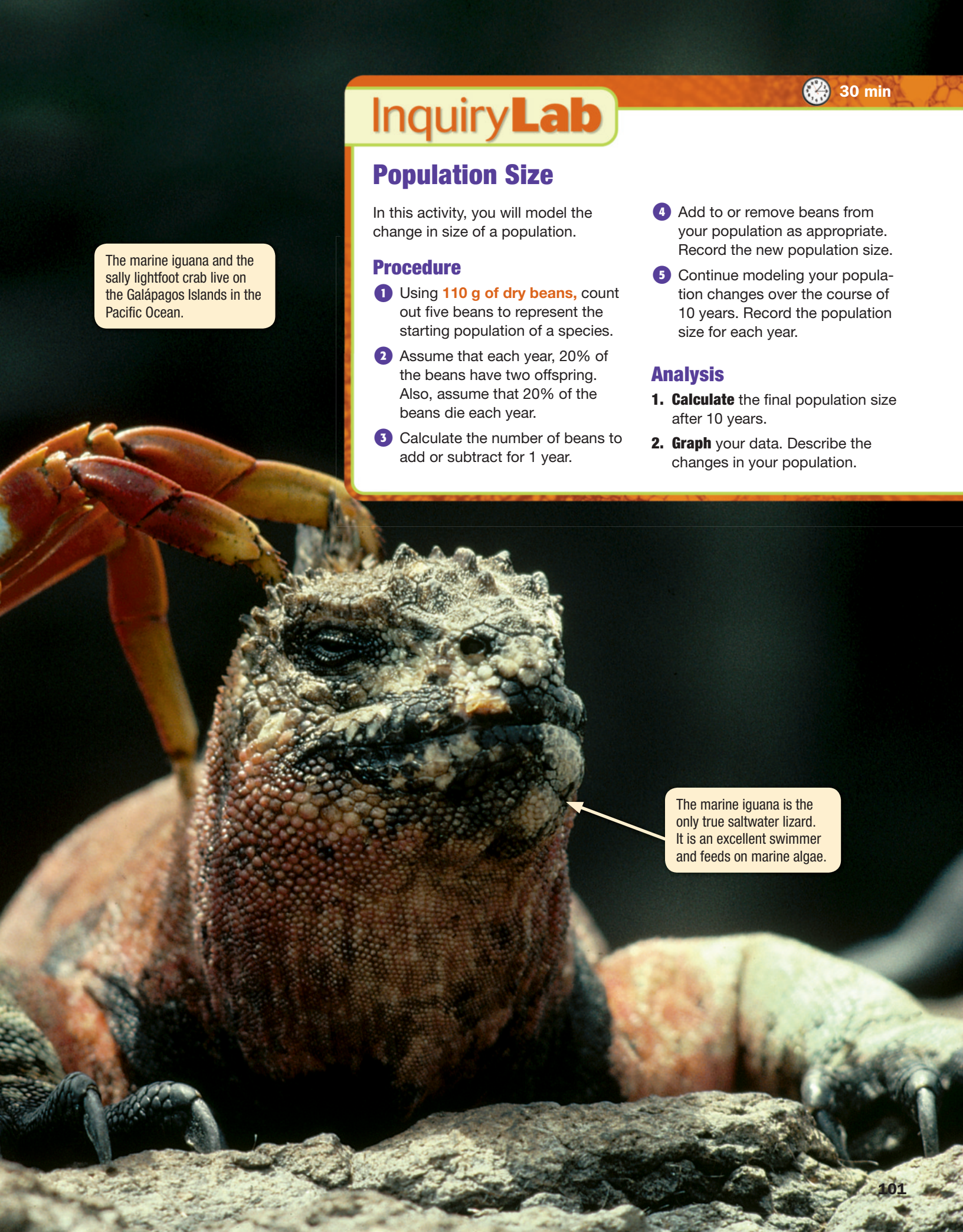


The marine iguana and the sally lightfoot crab live on the Galápagos Islands in the Pacific Ocean.

The marine iguana is the only true saltwater lizard. It is an excellent swimmer and feeds on marine algae.

30 min

InquiryLab

Population Size

In this activity, you will model the change in size of a population.

Procedure

1. Using **110 g of dry beans,** count out five beans to represent the starting population of a species.
2. Assume that each year, 20% of the beans have two offspring. Also, assume that 20% of the beans die each year.
3. Calculate the number of beans to add or subtract for 1 year.
4. Add to or remove beans from your population as appropriate. Record the new population size.
5. Continue modeling your population changes over the course of 10 years. Record the population size for each year.

Analysis

1. **Calculate** the final population size after 10 years.
2. **Graph** your data. Describe the changes in your population.

READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Word Origins Many common English words derive from Greek or Latin words. Learning the meanings of some Greek or Latin words can help you understand the meaning of many modern English words.

Your Turn Answer the following questions.

1. Why might an organism's role be called its *niche?*
2. Why might a tick on a dog be considered a parasite?

Word Origins

Word	Origin	Meaning
niche-	Latin *(nidus)*	nest
para-	Greek	beside
-site	Greek	food

Using Language

Predictions Some predictions are conditional: Something might happen, but only if something else happens first. For example, if the temperature drops below freezing, snow might fall. The prediction is that snow might fall tonight. But snow might fall under one condition. First, the temperature has to drop below freezing.

Your Turn In the following sentences, identify the condition and the prediction.

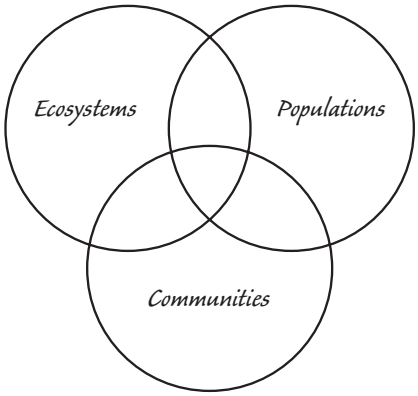
1. After the deer population reaches 600 individuals on the island, the deer will eat most of the vegetation, and the number of deer will decrease.
2. If the otters are removed from the ecosystem, the sea urchins will eat all of the kelp.

Using Graphic Organizers

Venn Diagram A Venn diagram is a useful tool for comparing two or three topics in science. A Venn diagram shows which characteristics are shared by the topics and which characteristics are unique to each topic.

Your Turn Create a Venn diagram that compares the characteristics of communities, ecosystems, and populations.

1. Draw a diagram like the one shown here. Draw one circle for each topic. Make sure that each circle partially overlaps the other circles.
2. In each circle, write a topic that you want to compare with the topics in the other circles.
3. In the areas of the diagram where circles overlap, write the characteristics that the topics in the overlapping circles share.
4. In the areas of the diagram where circles do not overlap, write the characteristics that are unique to the topic of the particular circle.



Section 1

Populations

Key Ideas	Key Terms	Why It Matters
❯ Why is it important to study populations? ❯ What is the difference between exponential growth and logistic growth? ❯ What factors affect population size? ❯ How have science and technology affected human population growth?	**population** **carrying capacity**	Understanding how populations grow and shrink is critical to managing agricultural pests and diseases and also for knowing how to protect ecosystems.

In the 1850s, about two dozen rabbits from Europe were introduced into Australia. The rabbits had plenty of vegetation to eat, no competition, and no predators. Their numbers increased rapidly. By the 1950s, there were 600 million rabbits! The rabbits ate so much vegetation that the numbers of native plants and animals declined and crops were damaged.

What Is a Population?

As Australia learned, understanding populations is important for protecting ecosystems. A **population** is made up of a group of organisms of the same species that live together in one place at one time and interbreed. **Figure 1** shows members of a zebra population. As new zebras are born, the population size increases. As other zebras fall prey to predators, the population decreases. Hundreds of miles away, there may be another zebra population that lives together and interbreeds.

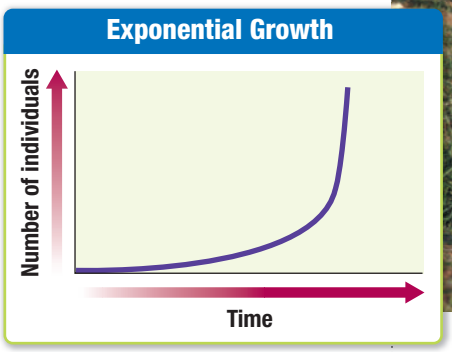
Populations can be small or large. Some populations stay at nearly the same number for years at a time. Some populations die out from lack of resources. Other populations grow rapidly, such as the rabbit population in Australia. The rapid growth of the rabbit population caused problems with Australia's ecosystems, other species, and farmland. ❯ **Understanding population growth is important because populations of different species interact and affect one another, including human populations.**

population a group of organisms of the same species that live in a specific geographical area and interbreed

❯ **Reading Check** ***What distinguishes one zebra population from another zebra population? (See Appendix for answers to Reading Checks.)***

Figure 1 This zebra population lives in Kenya near Mount Kilimanjaro.

Figure 2 Exponential growth is characterized by a J-shaped curve. Rabbits and bacteria are two examples of populations that can grow exponentially.



carrying capacity the largest population that an environment can support at any given time

Population Growth

One of the most basic questions ecologists ask is "How do populations grow and shrink?" To help answer this question, biologists make population models. A population model attempts to show key growth characteristics of a real population.

Whether a population grows or shrinks depends on births, deaths, immigration, and emigration. *Immigration* is the movement of individuals into a population. *Emigration* is the movement of individuals out of a population. So, a simple population model describes the rate of population growth as the difference between birthrate, death rate, immigration, and emigration. Plotting population changes against time on a graph creates a model in the form of a curve. Two major models of population growth are *exponential growth* and *logistic growth.*

Exponential Growth

One important part of a population model is the growth rate. When more individuals are born than die, a population grows. In exponential growth, there are always more births than deaths. As time goes by, more and more individuals enter the population. ❯ ***Exponential growth* occurs when numbers increase by a certain factor in each successive time period.** This type of increase causes the J-shaped curve of exponential growth seen in **Figure 2.**

In exponential growth, population size grows slowly when it is small. But as the population gets larger, growth speeds up. Bacteria are an example of a population that can grow exponentially. Populations of bacteria grow very fast. A single bacterial cell that divides every 30 minutes will have produced more than 1 million bacteria in 10 hours. Some populations, such as the rabbits shown in **Figure 2,** may grow exponentially for a while. If they continued to grow exponentially forever, the world would fill up with rabbits!

❯ **Reading Check** ***What are the characteristics of a population that grows exponentially?***

Data

30 min

QuickLab

Population Growth

You can learn a lot about a population by plotting its changes on a graph. In this activity, you will plot the growth of a deer population.

Procedure

1. On a graph, plot the data from the table.
2. Title the graph. Then, label the *x*-axis and the *y*-axis.

Analysis

1. **Identify** the dependent and independent variables.
2. **Describe** the growth curve. Does the population increase logistically or exponentially?
3. **Identify** the point at which the population is growing fastest.
4. CRITICAL THINKING **Analyzing Results** Are you able to determine the carrying capacity from this graph? If so, label it on the graph. What is its value?

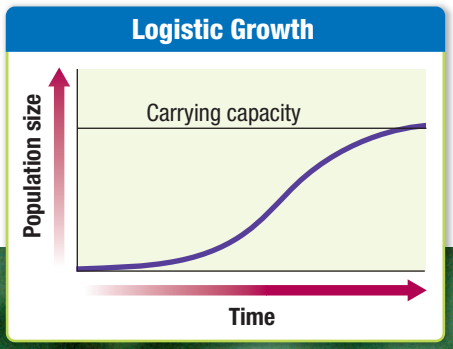
Year	Number of individuals
1930	30
1935	50
1940	98
1945	175
1950	250
1955	273
1960	201
1965	159
1970	185
1975	205
1980	194
1985	203

Logistic Growth Populations do not grow unchecked forever. Factors such as availability of food, predators, and disease limit the growth of a population. Eventually, population growth slows and may stabilize.

An ecosystem can support only so many organisms. The largest population that an environment can support at any given time is called the **carrying capacity.** *Density-dependent factors* are variables affected by the number of organisms present in a given area. An example of a density-dependent factor is the availability of nesting sites. As the number of adult birds increases, there are no longer enough nesting sites for the entire population. So, many birds will not have young, and growth of the population is limited. *Density-independent factors* are variables that affect a population regardless of the population density. Examples of density-independent factors are weather, floods, and fires.

The logistic model takes into account the declining resources available to populations. ❯ ***Logistic growth* is population growth that starts with a minimum number of individuals and reaches a maximum depending on the carrying capacity of the habitat.** When a population is small, the growth rate is fast because there are plenty of resources. As the population approaches the carrying capacity, resources become scarce. Competition for food, shelter, and mates increases between individuals of a population. As a result, the rate of growth slows. The population eventually stops growing when the death rate equals the birthrate. On a graph, logistic growth is characterized by an S-shaped curve, as **Figure 3** shows. Most organisms, such as the macaws shown in **Figure 3,** show a logistic growth pattern.

Figure 3 Logistic growth is characterized by an S-shaped curve.



Factors That Affect Population Size

Most populations increase or decrease. Some change with the seasons. Others have good years and bad years. Many factors cause populations to grow and shrink. ❯ **Water, food, predators, and human activity are a few of many factors that affect the size of a population.**

ACADEMIC VOCABULARY

affect to act upon

Abiotic Factors Nonliving factors that affect population size are called *abiotic factors.* Weather and climate are the most important abiotic factors. For example, the population size of the penguins shown in **Figure 4** is affected by the climate of Antarctica. Unusually low temperatures can reduce the number of young penguins that survive. The amount of water available can also influence populations. Kangaroo populations in Australia grew when farmers gave water to their livestock that was also available for kangaroos to drink.

READING TOOLBOX

Word Origins Write down the definitions of the words *biotic* and *abiotic*. Then, write down what you think that *bio-* means. Use a dictionary to check your answer.

Biotic Factors A factor that is related to the activities of living things is called a *biotic factor.* Food, such as grass or other animals, is a biotic factor. When there is plenty of food, populations tend to grow. When food is scarce, populations decline. Predators are another kind of biotic factor. When populations of Canadian lynx grow, they eat a lot of snowshoe hares. The population of hares is then reduced. Diseases and parasites, when they infect many individuals, can also cause populations to decline. Biotic factors are often density dependent because they can have a stronger influence when crowding exists. As the density of a population increases, the effects of starvation, predators, and disease often also increase.

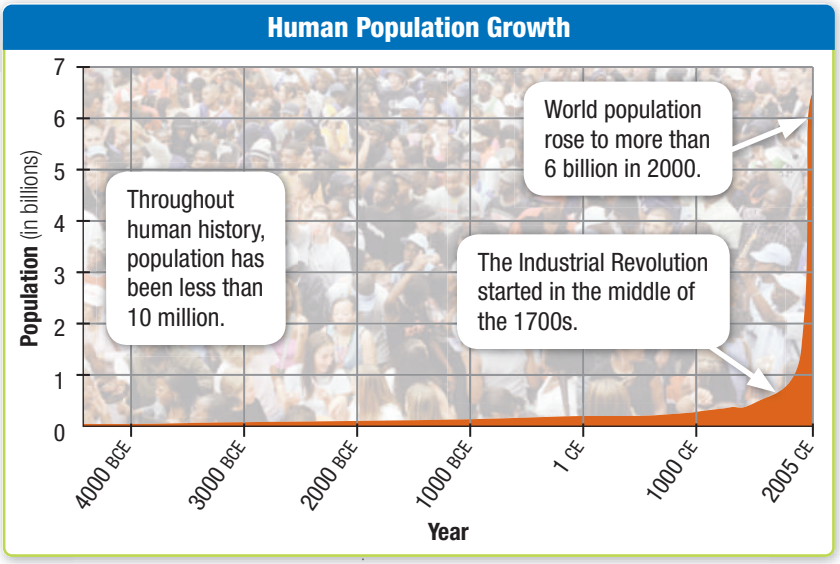
Humans affect populations of many species. Most of the time, humans cause populations to drop by disrupting habitats, introducing diseases, or introducing nonnative species. But some organisms do better around humans. Elk thrive near some Canadian towns because wolves will not come close to humans.

❯ **Reading Check** ***Describe the difference between biotic and abiotic factors.***

Figure 4 Climate is an abiotic factor that affects the population size of these emperor penguins in Antarctica. ❯ **Name another abiotic factor that may affect the population size of these penguins.**

Human Population

Today, the world population is more than 6 billion people and is increasing. **Better sanitation and hygiene, disease control, and agricultural technology are a few ways that science and technology have decreased the death rate of the human population.** As more humans live on the planet, more resources will be needed to support them. As demand for resources increases, more pressure will be put on Earth's ecosystems.



Source: U.S. Census Bureau.

Figure 5 During the last 200 years, the human population has grown exponentially.

Historic Growth For most of human history, there have been fewer than 10 million people. Once agriculture was developed, the population began to grow, but relatively slowly. Two thousand years ago, there were only 10 million people. Around the time of the Industrial Revolution, the human population started to accelerate rapidly. **Figure 5** shows the human population accelerating exponentially starting in the late 1700s. Now, there are more than 6 billion people, and some scientists think that the population will grow to 9 billion in 50 years. How many people Earth can support depends in part on science and technology.

Science and Technology Science and technology are major reasons why the human population is growing so rapidly. Advances in agricultural technology have allowed efficient production of crops and other foods. More food supports more people. As a result, the human population has begun to grow faster. Medical advances have also allowed the human population to increase. Vaccines have lowered the death rate. More children are surviving to adulthood. Other medical advances have allowed adults to live longer lives.

Reaching Check ***How have advances in technology allowed the human population to grow faster?***

Section 1 Review

KEY IDEAS

1. **Explain** the importance of studying populations.
2. **Compare** exponential growth with logistic growth.
3. **Identify** an abiotic factor that affects populations.
4. **Explain** how science and technology have affected human population growth.

CRITICAL THINKING

5. **Relating Concepts** A small species of mouse lives in a desert in Arizona. What factors do you think influence the size of this mouse population?
6. **Predicting Outcomes** Identify a biotic factor that could affect the size of the human population. Predict the effect of this biotic factor.

USING SCIENCE GRAPHICS

7. **Making Graphs** Draw a graph with a growth curve for a population that starts at 10 individuals and experiences exponential growth. Draw a second graph with a growth curve for a population that starts with 10 individuals and undergoes logistic growth. The second graph should have a carrying capacity of 100 individuals.

Why It Matters

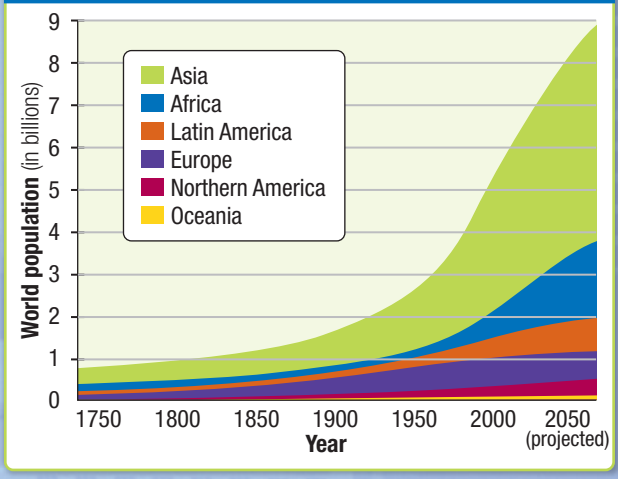
Growth in Asia

The world population is more than 6 billion and growing by about 9,000 people per hour. Most of the growth is coming from Asia. Because Asia's current population is already so large, one child per couple in Asia adds more to the world population than two children per couple in other areas of the world. As the world population continues to grow, pressure will increase on availability of food, energy, livable space, and landfill space.

A Recycling Society

As landfills quickly approach full capacity, the Japanese government has become a world leader in waste-recycling measures. Japan recycles refrigerators, washing machines, televisions, and even air conditioners. By 2015, Japan plans to recycle 95% of discarded cars. In the United States, 60% to 70% of waste is sent to landfills. In Japan, only 16% of waste is sent to landfills!

World Population Growth by Region, 1750–2050



Source: National Geographic

Old to New These workers in Tokyo, Japan, are dismantling computers and sorting the parts for recycling.

Crowed City With 6,380 people per square kilometer, Hong Kong, China, shown here, is one of the most densely populated regions of the world.

Research Identify four strategies used by various countries to slow the rate of population growth.

Section 2

Interactions in Communities

Key Ideas	Key Terms	Why It Matters
❯ How do predator-prey interactions influence both predators and prey? ❯ What are two other types of interaction in a community?	predation coevolution parasitism symbiosis mutualism commensalism	Interactions between organisms are the basis of communities and are shaped by evolution.

Interactions in communities can take many forms. Predators and prey are locked in a struggle for survival. Organisms with the same needs compete for food. Parasites and hosts try to get ahead of one another. Some organisms even depend on one another for survival.

Predator-Prey Interactions

One of the most common interactions in communities is that between predators and their prey. **Predation** is the act of one organism killing another for food. As **Figure 6** shows, predators try to get a meal, and prey do their best not to become one! We often think of predators as big animals, such as lions chasing zebras or sharks eating fish. Predators come in all sizes. Even microscopic organisms can be predators. In fact, most animals are both predators and prey. Only a few species, such as killer whales, are not hunted by any other animals.

Many interactions between species are the result of a long evolutionary history. Evolutionary changes in one species can result in changes in another species. ❯ **Species that involve predator-prey or parasite-host relationships often develop adaptations in response to one another.** For example, predators evolve to be more cunning to catch their prey. In response, prey evolve to be faster runners to escape more easily. Back-and-forth evolutionary adjustment between two species that interact is called **coevolution.**

predation an interaction between two organisms in which one organism, the predator, kills and feeds on the other organism, the prey

coevolution the evolution of two or more species that is due to mutual influence

Figure 6 This lion is hoping to have the zebra for lunch.

Data

QuickLab

15 min

The Effects of Herbivores on a Plant Species

Background

Some plant species, such as *Gilia,* respond to grazing by growing new stems. Consider the three images of *Gilia* to the right. Then, answer the statements below.

Ungrazed plant | Grazed plant | Regrowth after grazing

Analysis

1. **Identify** the plant that is likely to produce more seeds.
2. **Explain** how grazing affects this plant species.
3. **Evaluate** the significance to its environment of the plant's regrowth pattern.
4. **Hypothesize** how this plant species might be affected if individual plants did not produce new stems in response to grazing.

READING TOOLBOX

Venn Diagram Make a Venn diagram to help you compare the similarities and differences between predators, parasites, and herbivores.

parasitism a relationship between two species in which one species, the parasite, benefits from the other species, the host, which is harmed

symbiosis (SIM bie OH sis) a relationship in which two different organisms live in close association with each other

mutualism a relationship between two species in which both species benefit

commensalism a relationship between two organisms in which one organism benefits and the other is unaffected

Parasitism In **parasitism,** one organism feeds on another organism called a *host.* The host is almost always larger than the parasite and is usually harmed but not killed. Parasites often live on or in their host. Therefore, the parasite depends on its host not only for food but for a place to live as well. For example, tapeworms live in the digestive system of their hosts. Fleas that live on the skin of their host are another example.

Hosts try to keep parasites from infecting them. Hosts can defend themselves with their immune systems or behaviors such as scratching. In response, parasites may evolve ways to overcome the host's defenses.

Herbivory Herbivores are animals that eat plants. Unlike predators, herbivores do not often kill the plants. But plants do try to defend themselves. Some plants have thorns or spines that cause pain for herbivores that try to eat them. Other plants have chemical compounds inside them that taste bad. Some chemical compounds can make an herbivore sick or kill the herbivore.

Some herbivores have evolved ways to overcome plant defenses. For example, monarch butterfly caterpillars feed on milkweed, which is a plant that is toxic to many herbivores. Not only can the caterpillars survive eating the toxic milkweed but the plant toxins then make the monarch butterfly inedible to bird predators.

› **Reading Check** ***Identify one way in which herbivores and plants coevolve.***

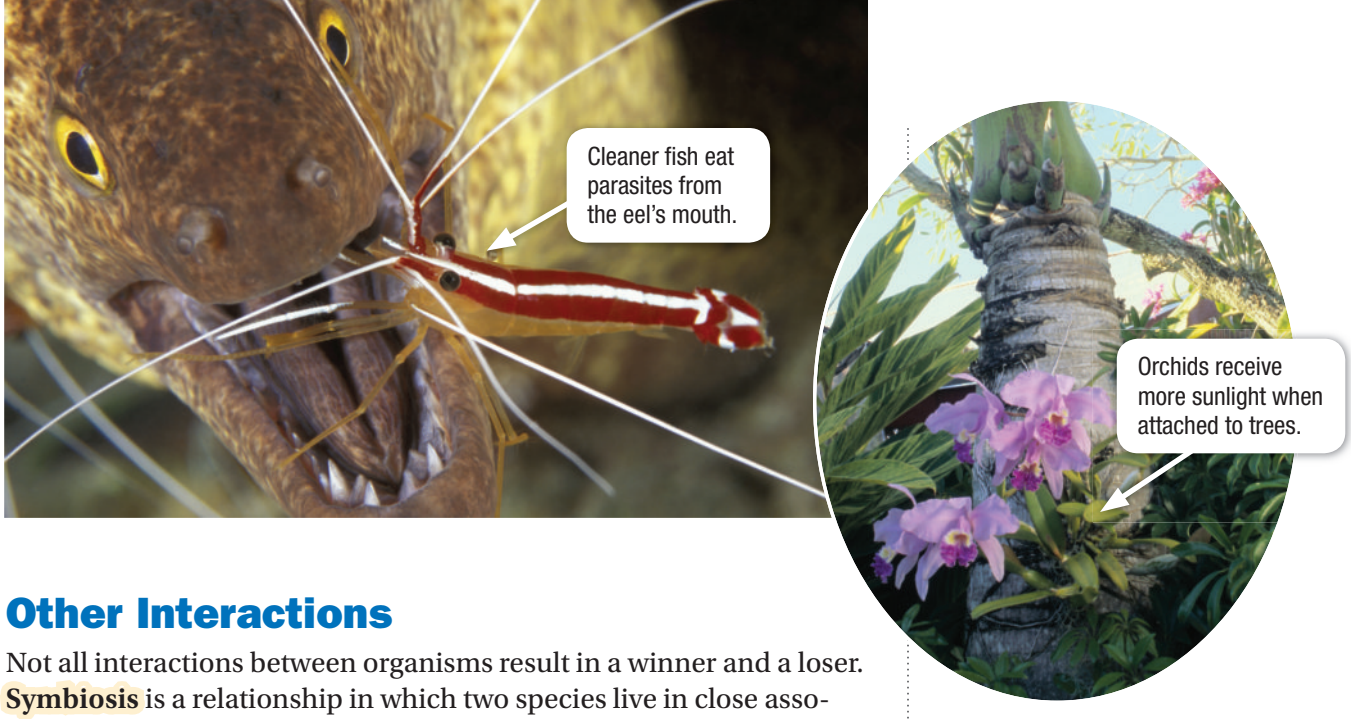


Figure 7 This yellow-edged moray eel is getting its mouth cleaned by a humpback cleaner shrimp. Orchids avoid the dark forest floor by attaching themselves to the trunks of trees. **Name another symbiotic relationship.**

Other Interactions

Not all interactions between organisms result in a winner and a loser. **Symbiosis** is a relationship in which two species live in close association with each other. In some forms of symbiosis, a species may benefit from the relationship. **Mutualism and commensalism are two kinds of symbiotic relationships in which at least one species benefits.**

Mutualism A relationship between two species in which both species benefit is called **mutualism.** Some shrimp and fishes on coral reefs clean the bodies of large fish and turtles. The cleaners even venture into the mouths of big predators that could easily swallow them, as **Figure 7** shows. Why don't the cleaners become an easy meal? The reason is that the big fish is having parasites removed by the cleaner. Because the cleaner gets a meal, both species win.

Commensalism In **commensalism,** two species have a relationship in which one species benefits and the other is neither harmed nor helped. **Figure 7** shows an example of commensalism between orchids and trees. In thick, tropical forests, little sunlight reaches the forest floor. Orchids need sunlight to survive. To reach the sunlight, orchids get a boost from the forest trees. Orchids will attach themselves and grow on the trunks of the trees. In this way, the orchids move up off the dark forest floor and closer to the sunny canopy.

Reading Check *Compare mutualism and commensalism.*

SCILINKS
www.scilinks.org
Topic: Symbiosis
Code: HX81486

Section 2 Review

KEY IDEAS

1. **Explain** how predator-prey interactions influence both predators and prey.
2. **Define** symbiosis.
3. **Describe** two types of relationships in a community.

CRITICAL THINKING

4. **Analyzing Results** The cookie-cutter shark feeds by taking a bite of flesh out of whales and large fish. The shark does not kill the larger fish it feeds on. Is the shark a predator or a parasite? Why?
5. **Relating Concepts** In commensalism, would both species coevolve?

WRITING FOR SCIENCE

6. **Essay** In a report, explain what might happen to an ecosystem if one species in a mutualistic relationship disappeared. What would happen if a new predator were introduced to prey with which it has not coevolved?

Section 3

Shaping Communities

Key Ideas	Key Terms	Why It Matters
How does a species' niche affect other organisms? How does competition for resources affect species in a community? What factors influence the resiliency of an ecosystem?	**niche** **fundamental niche** **realized niche** **competitive exclusion** **keystone species**	The interactions among organisms in communities shape the ecosystem and the organisms that live there.

No organism can live everywhere. Each organism has its own set of conditions where it can live and where it does best. Some plants, such as cactuses, can survive in deserts, but other plants need a lot of water. The desert plants cannot live in areas that have a lot of water because other plants outcompete them.

Carving a Niche

Think of your favorite plant or animal. How does it use the physical environment? How does it interact with other species? The unique position occupied by a species, both in terms of its physical use of its habitat and its function in an ecological community, is called a **niche.** A niche is not the same as a habitat. A *habitat* is the place where an organism lives. **A niche includes the role that the organism plays in the community. This role affects the other organisms in the community.** For example, the beaver shown in **Figure 8** cuts down trees with its sharp teeth. The beaver then uses the trees to make dams that divert, or redirect, water flow in rivers and streams. These actions directly affect the trees by killing the trees. These actions also affect organisms that depend on the trees for shelter or food. However, some plants would benefit: fewer trees would allow the plants access to more sunlight. Diverting water flow in a stream could be beneficial to some forms of aquatic life. For others, a dam in a stream could prevent them from traveling upstream to mating grounds. The beaver's role affects many other organisms. If you took the beaver out of this ecosystem, the community would be very different.

Reading Check ***How is a niche different from a habitat?***

Figure 8 Beavers build dams from trees and tree branches that they cut with their sharp, powerful teeth. **How might these dams affect other organisms in the community?**

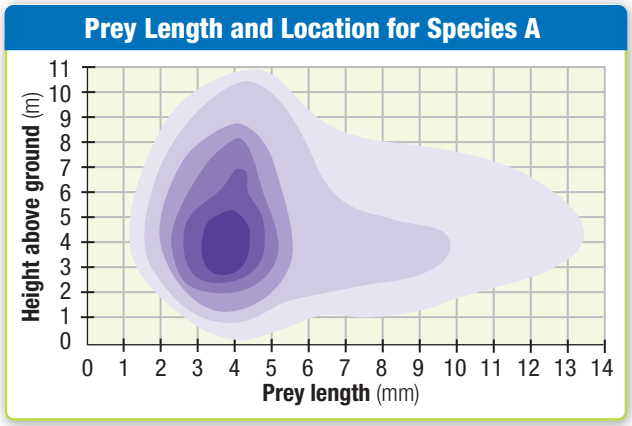
Data

QuickLab

15 min

Changes in a Realized Niche

This graph shows the location where species A feeds and the size of its preferred prey. The darkest shade in the center of the graph indicates the prey size and feeding location most frequently selected by species A.



Analysis

1. **State** the range of lengths of prey on which species A prefers to feed.
2. **Identify** the maximum height above ground at which species A feeds.
3. **Describe** what the palest shade at the edge of the contour lines represents.
4. CRITICAL THINKING **Predicting Outcomes** Species B is introduced into species A's ecosystem. Species B has the same feeding preferences but hunts at a different time of day. How might this affect species A?
5. CRITICAL THINKING **Interpreting Graphics** Species C is now introduced into species A's feeding range. Species C feeds at the same time of day as species A but prefers prey that are between 10 and 13 mm long. How might this change affect species A?

Competing for Resources

The entire range of conditions where an organism or species could survive is called its **fundamental niche.** Many species share parts of their fundamental niche with other species. Sometimes, species compete for limited resources. Because of this competition, a species almost never inhabits its entire fundamental niche. **Competition for resources between species shapes a species' fundamental niche.** The actual niche that a species occupies in a community is called its **realized niche.**

Sometimes, competition results in fights between rivals. Hyenas and lions will even steal food from one another. The stealing of food is called *kleptoparasitism.* Many competitive interactions do not involve direct contests. But when one individual takes a resource, the resource is no longer available for another individual. Many plants compete fiercely for access to light. Some do so by growing quickly to get above other plants. Other plants can tolerate periods of shade and grow slowly. As the slow-growing plants become larger, they eventually shade out other plants.

Competition has several possible outcomes. Sometimes, one species wins, and the other loses. The loser is eliminated from the habitat. Other times, competitors can survive together in the same habitat. They are able to survive together because they divide the resources.

Reading Check *Why do organisms rarely occupy their entire fundamental niche?*

niche the unique position occupied by a species, both in terms of its physical use of its habitat and its function within an ecological community

fundamental niche the largest ecological niche where an organism or species can live without competition

realized niche the range of resources that a species uses, the conditions that the species can tolerate, and the functional roles that the species plays as a result of competition in the species' fundamental niche

SCILINKS
www.scilinks.org
Topic: Habitats and Niches
Code: HX80707

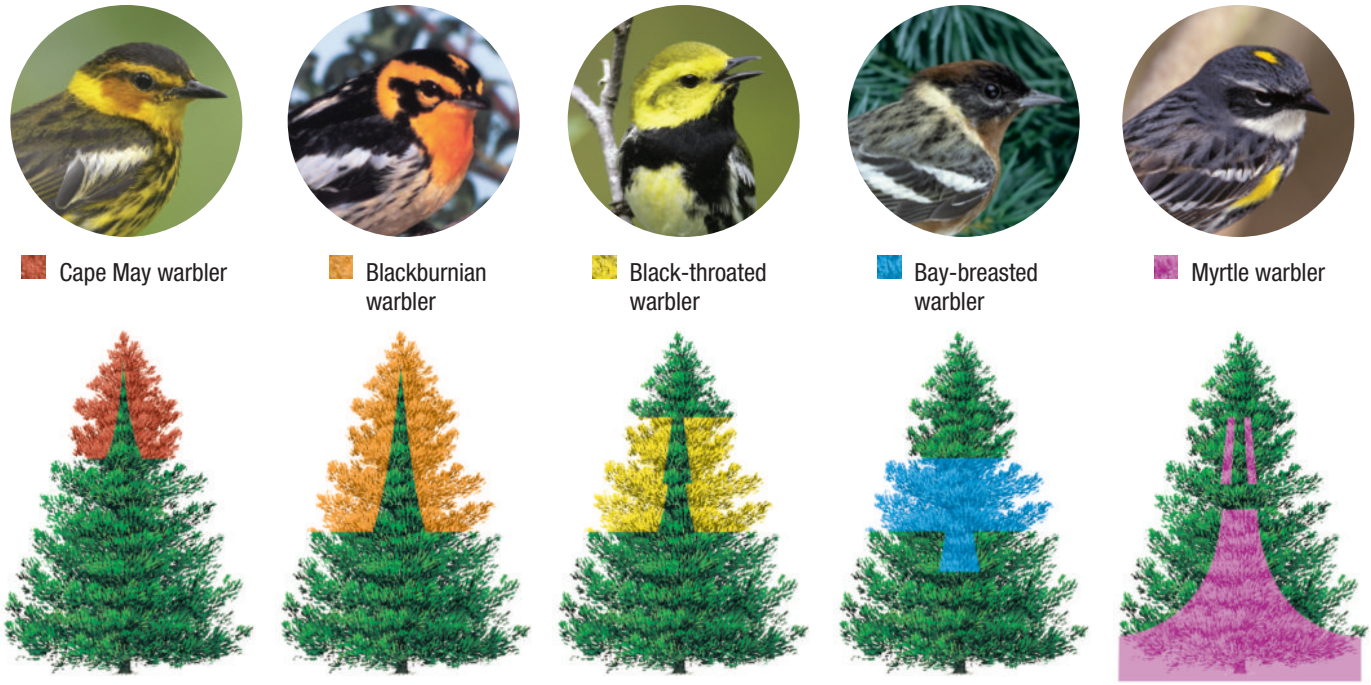


Figure 9 Each of these five warbler species feeds on insects in a different portion of the same tree, as indicated by the five colors shown in the figure.

competitive exclusion the exclusion of one species by another due to competition

keystone species a species that is critical to the functioning of the ecosystem in which it lives because it affects the survival and abundance of many other species in its community

ACADEMIC VOCABULARY

potential possible

Competitive Exclusion No two species that are too similar can coexist. Why? If species are too similar in their needs, one will be slightly better at getting the resources on which they both depend. The more successful species will dominate the resources. The less successful species will either die off or have to move to another ecosystem. Eventually, the better competitor will be the only one left. One species eliminating another through competition is called **competitive exclusion.**

Competitive exclusion is seen in many places. When there are no predators around, mussels take over all of the space on rocks in the surf zone. The mussels eliminate barnacles from the surf-zone rocks that are part of the mussels' fundamental niche. Introduced species can also competitively exclude native species. When introduced species multiply quickly, they can use up all of the available resources. When resources are used up, other species that depend on the resources may become extinct.

Dividing Resources Sometimes, competitors eat the same kinds of food and are found in the same places. How do these species live together? Some competitors divide resources by feeding in slightly different ways or slightly different places. The five warblers shown in **Figure 9** are all potential competitors. All five species feed on insects in the same spruce trees at the same time. But they divide the habitat so that they do not compete. Each species feeds in a different part of the tree. Every one of the warbler species would feed everywhere in the tree if it had the tree to itself. Therefore, all the warbler species have the same fundamental niche. But when they are all present in the tree, they each have a smaller realized niche.

› **Reading Check** ***How might two different species divide resources?***

Ecosystem Resiliency

Ecosystems can be destroyed or damaged by severe weather, humans, or introduced species. Some factors can help keep an ecosystem stable. **› Interactions between organisms and the number of species in an ecosystem add to the resiliency of an ecosystem.**

Predation and Competition Predation can reduce the effects of competition among species. Many aquatic species compete for space in the intertidal zone along the Pacific coast. Mussels are fierce competitors that can take over that space. All other species are excluded. However, sea stars eat mussels. When sea stars eat the mussels, a variety of species can live in the intertidal zone.

Predators can influence more than their prey. Sea otters, as shown in **Figure 10,** eat sea urchins. Sea urchins eat kelp. When sea otters are present, lush kelp forests grow along the west coast of North America. These kelp forests provide habitat for many fishes and aquatic animals. When sea otters disappeared because of overhunting, the sea urchins ate all of the kelp. All of the species that depended on the kelp also disappeared. Sea otters are an example of a keystone species. A **keystone species** is a species that is critical to an ecosystem because the species affects the survival and number of many other species in its community.

Biodiversity and Resiliency One community has 50 species. Another community has 100 species. If a severe drought affected both communities equally, the community with 100 species would be more likely to recover quickly. The reason is that higher biodiversity often helps make an ecosystem more resilient. Predation helps increase biodiversity. The sea stars prevented the mussels from excluding other species. In response, the inter tidal zone had a higher biodiversity.

› Reading Check ***List two factors that contribute to the resiliency of an ecosystem.***

Figure 10 Sea otters off the coast of California are a threatened species. The decrease in their population has affected the stability of the ecosystem. **› Why is the sea otter considered a keystone species?**

READING TOOLBOX

Predictions Using the term *keystone species,* write a sentence with a prediction based on a condition.

Section 3

Review

› KEY IDEAS

1. **Explain** why an organism's role is important for a community.
2. **Describe** one example of how competition for resources affects species in a community.
3. **Explain** how predation can help make an ecosystem resilient.
4. **Compare** niche and habitat.

CRITICAL THINKING

5. **Inferring Conclusions** Two predators feed on small antelope. One predator weighs 100 kg, and the other weighs 35 kg. Explain what might happen if the two predators share the same area.
6. **Evaluating Results** Wolves are reintroduced into a park. As a result, the vegetation changes. Explain how the changes to the vegetation happened.

ALTERNATIVE ASSESSMENT

7. **Essay** Search the Internet to find out about the niche of wolves in their community. Determine if they are a keystone species. Then, write a one-page essay describing their role in their ecosystem.

Chapter 5 **Lab**

Objectives

- Observe the growth and decline of a population of yeast cells.
- Determine the carrying capacity of a yeast culture.

Materials

- lab apron, safety goggles, and gloves
- yeast cell culture
- test tube (2)
- pipets, 1 mL (2)
- methylene blue solution, 1%
- microscope slide, ruled
- coverslip
- microscope, compound

Safety

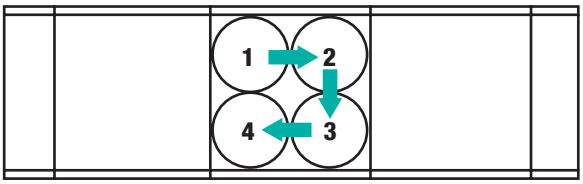
Yeast Population Growth

You have learned that a population will keep growing until limiting factors slow or stop this growth. 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

Collecting Data

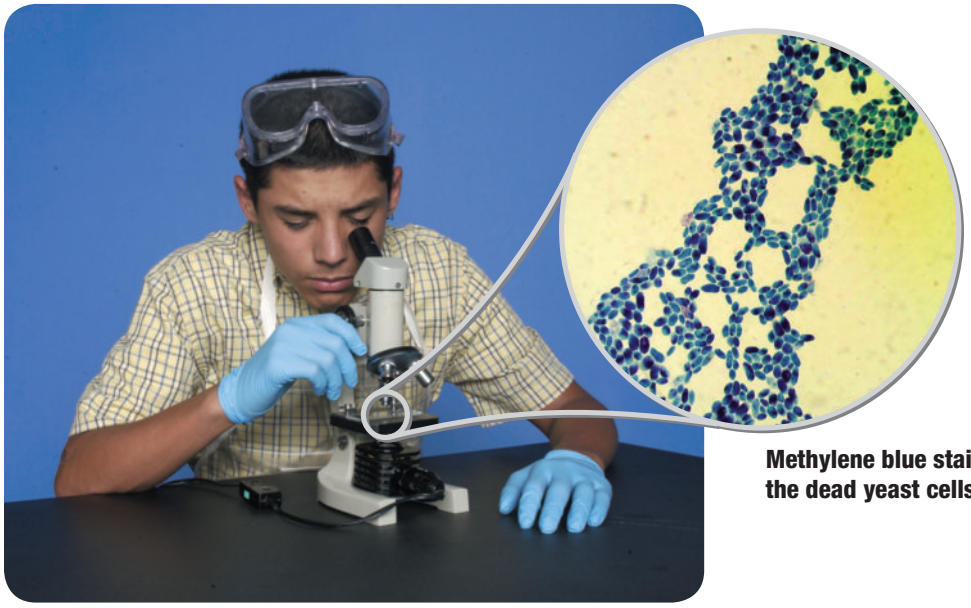
1. **CAUTION: Do not touch or taste any chemicals. Know the location of the emergency shower and eyewash station and how to use them. Methylene blue will stain your skin and clothing.** Transfer 1 mL of yeast culture to a test tube. Add two drops of methylene blue to the test tube. The methylene blue will remain blue in dead cells but will turn colorless in living cells.
2. Make a wet mount by placing 0.1 mL, or about one drop, of the yeast culture and methylene blue mixture on a ruled microscope slide. Cover the slide with a coverslip.
3. Observe the wet mount under low power of a compound microscope. Notice the squares on the slide. Then, switch to high power. (Note: Adjust the light so that you can clearly see both stained and unstained cells.) Move the slide so that the top left-hand corner of one square is in the center of your field of view. This area will be area 1, as shown in the diagram.



4. Make two data tables like the one shown. One table will contain your observations of living cells. The other table will contain your observations of dead cells.

Number of cells

Time (h)	1	2	3	4	5	6	Average
0							
24							
48							
72							
96							



Methylene blue stains the dead yeast cells.

5. Count the live (unstained) cells and the dead (stained) cells in the four corners of a square by using the pattern shown in the diagram in step 3. Record the number of live cells and dead cells that you counted in the entire square.
6. Repeat step 5 until you have counted all six squares on the slide.
7. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

Compiling Data

8. Refer to your first data table. Find the total number of live cells in the six squares. Divide this total by 6 to find the average number of live cells per square. Record this number in your data table. Repeat this procedure for the dead cells.
9. Repeat steps 1 through 5 each day for four more days.

SCILINKS
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Topic: Characteristics of Populations
Code: HX80260

Analyze and Conclude

1. **Evaluating Methods** Explain why several areas were counted and averaged each day.
2. **Analyzing Data** Graph the changes in the numbers of live yeast cells and dead yeast cells over time. Plot the number of cells in 1 mL of yeast culture on the *y*-axis and the time (in hours) on the *x*-axis.
3. **Evaluating Results** Describe the general population changes that you observed in the yeast cultures over time.
4. SCIENTIFIC METHODS **Inferring Conclusions** Did the yeast population appear to reach a certain carrying capacity? What limiting factors probably caused the yeast population to decline?

Extensions

5. **Designing an Investigation** Write a question about population growth that could be explored in another investigation. Design an investigation that could help answer that question.

Chapter 5 Summary

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SUPER SUMMARY
Keyword: HX8COMS

Key Ideas	Key Terms

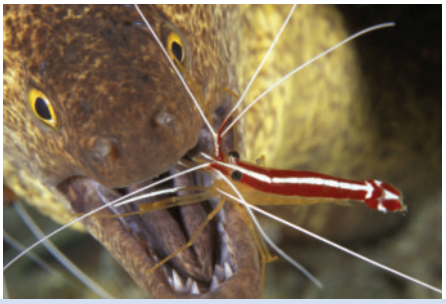
1 Populations

- Understanding population growth is important because populations of different species interact and affect one another, including human populations.
- Exponential growth occurs when numbers increase by a certain factor in each successive time period. Logistic growth is population growth that starts with a minimum number of individuals and reaches a maximum depending on the carrying capacity of the habitat.
- Water, food, predators, and human activity are a few of many factors that affect the size of a population.
- Better sanitation and hygiene, disease control, and agricultural technology are a few ways that science and technology have decreased the death rate of the human population.

population (103)
carrying capacity (105)

2 Interactions in Communities

- Species that involve predator-prey or parasite-host relationships often develop adaptations in response to one another.
- Mutualism and commensalism are two types of symbiotic relationships in which one or both of the species benefit.



predation (109)
coevolution (109)
parasitism (110)
symbiosis (111)
mutualism (111)
commensalism (111)

3 Shaping Communities

- A niche includes the role that the organism plays in the community. This role affects the other organisms in the community.
- Competition for resources between species shapes a species' fundamental niche.
- Interactions between organisms and the number of species in an ecosystem add to the stability of an ecosystem.

niche (112)
fundamental niche (113)
realized niche (113)
competitive exclusion (114)
keystone species (115)

Chapter 5 Review

READING TOOLBOX

1. **Venn Diagram** Make a Venn diagram to help you compare the similarities and differences between niche, realized niche, and fundamental niche.
2. **Concept Map** Draw a concept map that shows characteristics of a population. Try to include the following words in your map: *mutualism, commensalism, predation, abiotic factors, biotic factors, population, parasitism, carrying capacity, logistic growth,* and *exponential growth.*

Using Key Terms

Use each of the following terms in a separate sentence.

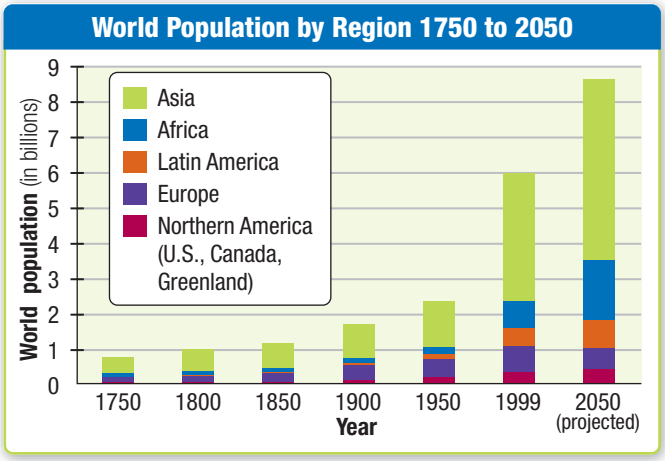
3. *population*
4. *competitive exclusion*

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

5. *exponential growth* and *logistic growth*
6. *immigration* and *emigration*

Understanding Key Ideas

7. Which of the following is an abiotic factor that could influence population size?
   - **a.** amount of food
   - **b.** amount of water
   - **c.** presence of predators
   - **d.** presence of competitors
8. Which of the following has *not* been a factor in decreasing the death rate of the human population?
   - **a.** vaccine
   - **b.** disease
   - **c.** Industrial Revolution
   - **d.** agricultural technology
9. Which of the following describes a relationship between two species in which one species benefits and the other is unaffected?
   - **a.** predation
   - **b.** mutualism
   - **c.** parasitism
   - **d.** commensalism
10. Which of the following is *not* an example of coevolution?
    - **a.** Prey evolve faster running to escape, and predators evolve to be smarter at catching prey.
    - **b.** Predators evolve heavy jaws to crunch the bones of herbivores, and herbivores evolve thick fur for warmth.
    - **c.** Plants evolve chemical defenses, and herbivores evolve ways to neutralize the chemicals.
    - **d.** Insects evolve green wings to blend into the environment, and predators evolve better eyesight to find the prey.
11. Which of the following describes an organism's role in a community?
    - **a.** niche
    - **b.** abiotic factor
    - **c.** habitat
    - **d.** coevolution
12. Which of the following may help stabilize an ecosystem?
    - **a.** severe weather
    - **b.** invasive species
    - **c.** low biodiversity
    - **d.** high biodiversity
13. Which region of the world will contribute the least to world population in 2050?

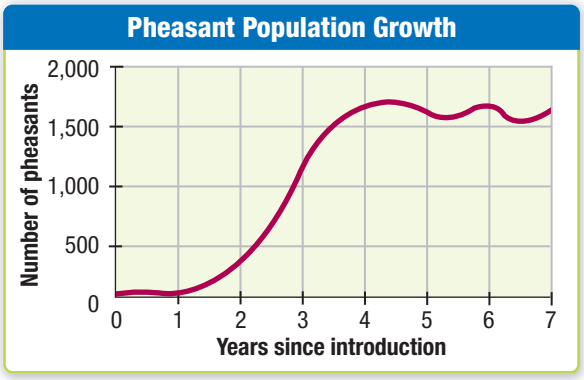


Explaining Key Ideas

14. **List** three factors that could affect population size.
15. **Describe** what has happened to the human population since the Industrial Revolution.
16. **Explain** how predators and parasites differ in their effect on the organisms on which they feed.

Using Science Graphics

Use the diagram to answer the following questions.



17. Biologists introduced pheasants onto an island in Washington State in the 1930s. Using the data in the graph, estimate the number of pheasants on the island two years after they were first introduced.

18. Estimate the island's carrying capacity for pheasants.

Critical Thinking

19. Evaluating an Argument A classmate tells you that the boundaries of human populations are at the borders of countries. Is your classmate correct? Explain why or why not.

20. Forming Reasoned Opinions Why is it important to know and understand human population growth?

21. Making Comparisons Differentiate between mutualism, commensalism, and symbiosis.

22. Evaluating Conclusions You watch a television program that states that biological communities are shaped by interactions between predators and prey and that organisms must always struggle with one another for existence. Do you agree? Explain why or why not.

23. Predicting Outcomes How might population size influence the chances that a population will grow, shrink, or become extinct?

24. Evaluating Models Is a population growth model that is based on exponential growth more or less realistic than a population growth model that is based on logistic growth? Explain your answer.

Writing for Science

25. Comparing Relationships Write an essay describing several examples of how humans can influence the size of populations.

26. Analyzing Results In an essay, explain why few populations grow exponentially for long periods of time. Include in your argument factors that influence population growth.

Methods of Science

27. Forming Hypotheses You measure the conditions under which a species, cattail, can survive when there are no competitors around. Next, you introduce another species of closely related cattail in the same area. Hypothesize what will happen to the niche of the first cattail.

28. Designing an Experiment You want to find out how a highway cut through a forest would affect the biodiversity of the forest. You decide to compare the biodiversity of two similar forests, one with a highway and one without. Design an investigation that measures and compares the number and types of species in each forest.

Alternative Assessment

29. Recognizing Relationships Use Internet resources to find out about the niche of your favorite organism. Write an essay describing this organism's role in an ecosystem. Include a description of the organism's fundamental niche and realized niche.

30. Forming Hypotheses Formulate a hypothesis about human population growth. Then, use library or Internet resources to find estimates of the current rate of human population growth and forecasts for future growth. Predict trends from the data, and communicate your conclusions in the form of a report to your class.

Math Skills

31. Problem Solving A population of bacteria has two individuals. If the population doubles in size with each generation, how many bacteria will there be in the eighth generation? Assume that there are no deaths.

Chapter 5 Standardized Test Prep

TEST TIP If you are unsure of the correct answer to a multiple-choice question, start by crossing out answers that you know are wrong. Reducing your choices in this way may help you choose the correct answer.

Science Concepts

1. Which of the following is a biotic factor that could influence population growth?

A water
B climate
C temperature
D the presence of predators

2. What is the human population projected to be 50 years from now?

F 3 billion
G 6 billion
H 9 billion
J 50 billion

3. Which of the following describes the actual role of a species in a community in response to competition?

A niche
B actual niche
C realized niche
D fundamental niche

4. When two closely matched competitors occupy the same area, what happens to the size of their fundamental niches?

F Both increase.
G Both decrease.
H Both stay the same.
J One increases, and one decreases.

5. What do you call a species that has a huge impact on an ecosystem even if the species is not very abundant?

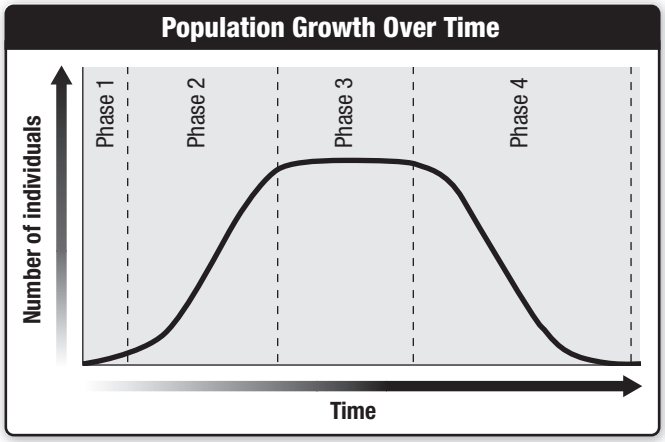
A parasite
B competitor
C top predator
D keystone species

6. Which of the following is a density-independent factor?

F food
G water
H predators
J hurricanes

Using Science Graphics

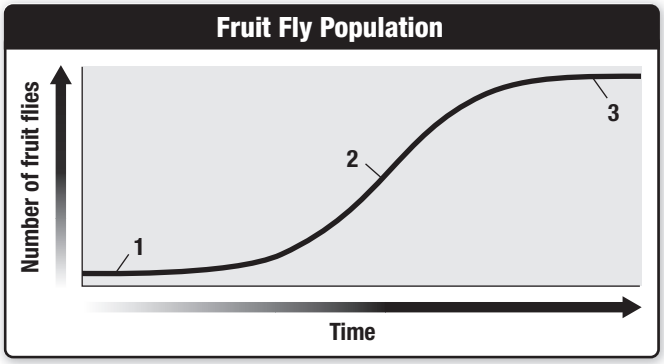
The diagram below shows the size of a particular population over time. Use the diagram to answer the following question.



7. Which time period shows negative growth of the population?

A phase 1
B phase 2
C phase 3
D phase 4

The diagram below shows the growth of a population of fruit flies over time. Use the diagram to answer the following question.



8. At which point would a density-dependent factor have a greater impact on the population?

F point 1
G point 2
H point 3
J points 1 and 3

Writing Skills

9. Essay In the Fruit Fly Population diagram, explain why the population stops increasing after it reaches point 3 on the curve.

Chapter 6

The Environment

The Neversink Pit in Alabama has recently been bought by local cavers who plan to preserve its ecosystem.

Preview

Why It Matters

The environment provides the basic support system for all life on Earth, including humans. By taking care of the environment, we take care of ourselves and all other life on Earth.

Neversink is an open air pit that is 162 ft deep.

A rare species of fern lives in the Neversink Pit.