### Chapter 4 Organizer

#### Population Biology

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<td><strong>MiniLab 4-1:</strong> Fruit Fly Population Growth, p. 96  <strong>Inside Story:</strong> Population Growth, p. 98  <strong>Problem-Solving Lab 4-1,</strong> p. 99  <strong>Investigate BioLab:</strong> How can you determine the size of an animal population? p. 108  <strong>Chemistry Connection:</strong> Poly styrene: Friend or Foe? p. 110</td>
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**MATERIALS LIST**

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| Key to Teaching Strategies | Level 1 activities should be appropriate for students with learning difficulties. | Level 2 activities should be within the ability range of all students. | Level 3 activities are designed for above-average students. | ELL activities should be within the ability range of English Language Learners. |

**Teacher Classroom Resources**

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| **Section 4.2** Human Population Growth | Reinforcement and Study Guide, pp. 17-18  Biolo and MiniLab Worksheets, pp. 18-20 | **Content Mastery,** pp. 17, 19-20 |

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**Teacher’s Corner**

|---------------------|-----------------------------------------------|

**GLENCOE TECHNOLOGY**

The following multimedia resources are available from Glencoe.  
**Biology: The Dynamics of Life**  
**CD-ROM**  
**BioQuest: Antarctic Food Web**  
**Animation: Carrying Capacity**  
**Videodisc Program**  
**Carrying Capacity**  
**The Infinite Voyage**  
**The Keepers of Eden**  
**The Secret of Life Series**  
**Competition**  
**Predator-Prey**  
**Gone Before You Know It: The Biodiversity Crisis”**

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*Note: ELL = English Language Learners; COOP LEARN = Cooperative Learning activities are designed for small group work. These strategies represent student products that can be placed into a best-work portfolio. These strategies are useful in a block scheduling format.*
Chapter 4

Population Biology

What You’ll Learn

You will explain how populations grow.
You will identify factors that inhibit the growth of populations.
You will summarize forces behind and issues in human population growth.

Why It’s Important

How a population grows is critical to its niche. A population that becomes too large too quickly may run out of food and space, and disease spreads more easily through large populations; a population that grows too slowly may become extinct.

Reading Biology

Carefully read the “Inside Story: Population Growth” on page 98. Observe the five numbered stages of population growth. Choose a specific animal and its habitat. Describe how each stage of population growth would unfold for the animal and impact the surrounding environment.

Theme Development

The theme of systems and interactions is illustrated as changes in populations (the system) result from interactions occurring within the population.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities:

- Kinesthetic: Project, p. 96
- Linguistic: Biology Journal, pp. 97, 99; Portfolio, p. 104; Activity, p. 107
- Visual-Spatial: Project, p. 98; Portfolio, p. 98; Meeting Individual Needs, p. 102
- Logical-Mathematical: Enrichment, p. 97; Activity, p. 103; Tech Prep, p. 104

Portfolio Assessment

- Portfolios, TWE, pp. 98, 104
- Problem-Solving Lab, TWE, p. 99
- Assessment, TWE, p. 103
- MiniLab, TWE, p. 105
- Performance Assessment, SE, pp. 96, 105
- Assessment, TWE, pp. 100, 107
- Alternative Lab, TWE, pp. 100-101
- BioLab, SE, p. 109

Knowledge Assessment

- Section Assessment, SE, pp. 103, 107
- Chapter Assessment, SE, pp. 111-113

Skill Assessment

- MiniLab, TWE, p. 96
- Assessment, TWE, pp. 102, 105
- BioLab, TWE, p. 109

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1 Focus

Bellringer

Before presenting the lesson, display Section Focus Transparency 8 on the overhead projector and have the students answer the accompanying questions.  

Prepare

Key Concepts

Population growth is the increase in population size over time. Students learn that population growth, while exponential at times, is controlled by limiting factors that determine the carrying capacity of the environment. Such limits to population growth may result from predation, prey interactions or overcrowding.

Planning

- Purchase bananas and gather jars and mesh for MiniLab 4-1.
- Purchase radish seeds. Gather petri dishes and napkins for the Alternative Lab.

SECTION PREVIEW

Population Dynamics

Objectives

- Compare and contrast exponential and linear population growth.
- Relate the reproductive patterns of different populations of organisms to models of population growth.
- Predict effects of environmental factors on population growth.

Vocabulary

- Exponential growth: carrying capacity
- Density-dependent factor
- Density-independent factor

Principles of Population Growth

How and why do populations grow? Population growth is defined as an increase in the size of a population over time. Scientists use a variety of methods to investigate population growth in organisms, as shown in Figure 4.1. One method involves placing microorganisms, such as bacteria or yeast cells, into a tube or bottle of nutrient solution and observing how rapidly the population grows. Another method involves introducing

Figure 4.1

EcoLogists can study population growth by inoculating a petri dish containing a nutrient medium with a few organisms and watching their growth.
of weeds in a field, frogs in a pond, or humans in a city, the initial increase in the number of organisms is slow because the number of reproducing organisms is small. Soon, however, the rate of population growth increases rapidly because the number of potentially reproducing organisms increases. This pattern illustrates the exponential nature of population growth. Exponential growth means that as a population gets larger, it also grows faster. Exponential growth, as illustrated in Figure 4.3, results in a population explosion.

Limits of the environment
Can a population of organisms grow indefinitely? What prevents the world from being overrun with all kinds of living things? In population experiments, scientists have found that, fortunately, population growth does have limits. Eventually, limiting factors, such as availability of food and space, will stop a population from growing. In time, this leveling-off of population size results in an S-shaped growth curve.

The number of organisms of one species that an environment can support is its carrying capacity. When populations are under the carrying capacity of a particular environment, births exceed deaths until population levels are once again below carrying capacity. Thus, the number of organisms in a population is sometimes more than the carrying capacity and sometimes less. Learning how to determine population size by completing the BioLab at the end of this chapter. When the population falls below the carrying capacity, the population tends to increase; when it is above the carrying capacity, the population tends to decrease. Do all populations follow the same growth pattern? Find out in the Inside Story on the next page.

Patterns of population growth
In nature, many animal and plant populations change in size. Why, for example, does it seem like mosquitoes or fruit flies have the potential for explosive growth?

Exponential growth patterns are possible in nature. The two extremes of this range are demonstrated by the population growth rates of both mosquitoes and elephants. Mosquitoes reproduce very rapidly and produce many offspring in a short period of time. Elephants have a slow rate of reproduction and produce relatively few young over their lifetimes. What causes these species to have different life-history patterns?

Reinforcement
Explain that while linear growth may be shown by height increases in children, it does not reflect the growth pattern of most populations.

Chalkboard Example
Graph two lines onto the same axis using different colors of chalk. Have one line show linear growth, and the other line show exponential growth. Ask students to describe how the patterns differ. Point out that when the curves begin, differences are smaller than at the end points.

Enrichment
Logical-Mathematical
Have students make the calculations needed to decide if they would rather be paid a linear salary of $5.00 per hour for a 40- hour week or an exponential salary that starts at 1 cent the first hour and doubles each hour up to 40 hours. The exponential salary will exceed the linear salary many times over.

The BioLab at the end of the chapter can be used at this point in the lesson.

MiniLab 4-1
Making and Using Tables
Fruit Fly Population Growth
Purpose: To study population growth of fruit flies.
Procedure: Place half of a banana in a jar and allow it to sit outside in a warm shaded area, or put it in a warm area in your classroom.
1. Leave the jar undisturbed for one day until you have at least three fruit flies in it. Put the mesh on top of the jar and fasten it with the rubber band. Each day record how many adult fruit flies are alive in the jar. Record for at least three weeks. Put your data into tabular form. CAUTION: Return the fruit flies to your teacher for proper disposal.
Analysis: 1. How many fruit flies did you start with? On what day were there the most fruit flies? How many were there?
2. Why did the number of fruit flies decrease?
3. Based on this investigation, why are insects considered to display a rapid reproduction pattern?

Figure 4.2 The way you earn money at an hourly rate is a straight line graph. Other examples might include the growth of your weekly allowance or the number of eggs produced by an assembly line each month.

Money Earned Per Hour
0 1 2 3 4 5 10 15 20 25 30 35
Time in Hours
0 10 20 30 40
$0 $10 $20 $30
$40

Table 4.1
<table>
<thead>
<tr>
<th>Time in Hours</th>
<th>Money Earned Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>1</td>
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<td>30</td>
<td>150</td>
</tr>
<tr>
<td>40</td>
<td>200</td>
</tr>
</tbody>
</table>

Expected results
Fruit flies will arrive and quickly reproduce. Larvae will be evident because the food supply is limited. You can obtain wingless fruit flies from a biological supply company.

Teaching Strategies
1. If temperatures are warm enough, fruit flies should be attracted quickly to the banana. You can obtain wingless fruit flies from a biological supply company.
2. Have students record their data and observations in a table.

Safety Precautions
1. Place half of a banana in a jar and allow it to sit outside in a warm shaded area, or put it in a warm area in your classroom.
2. Each day record how many adult fruit flies are alive in the jar. Record for at least three weeks. Put your data into tabular form. CAUTION: Return the fruit flies to your teacher for proper disposal.
3. Have students wash their hands after each observation.

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**Population Growth**

When organisms are in an optimal environment, they flourish. From a few pioneers, the population increases. Ecologists have discovered that these population increases show a pattern. Whether it is a plant or animal, whether on land or in the ocean, populations grow in predictable manners.

### Critical Thinking

**Why does the population fluctuate once it reaches carrying capacity?**

Humpback whales have a long life-history, living up to thirty years. The kind of reproductive pattern a species has depends mainly on environmental conditions. For example, species such as mosquitoes are successful in environments that are unpredictable and change rapidly. Rapid life-history patterns are found in organisms from unpredictable environments. Typically, these organisms have a small body size, mature rapidly, reproduce early, and have a short life span. Populations of these organisms increase rapidly, then decline rapidly as environmental conditions suddenly change and become unsustainable. The small surviving population will begin reproducing exponentially when conditions are again favorable. The Problem-Solving Lab on this page will allow you to observe an organism with this type of a life-history pattern, bacteria.

Species that live in more stable environments, such as elephants, often have a different life-history pattern. Elephants, humans, bears, whales, and long-lived plants, such as cacti and bristlecone pine shown in Figure 4.4, are large, reproduce and mature slowly, and are long-lived. These organisms maintain population sizes near the carrying capacities of their environments. Although populations could display a variety of life-histories, under

### Reproduction Rates

<table>
<thead>
<tr>
<th>Time (in hours)</th>
<th>Number of Bacteria</th>
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</tr>
<tr>
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</tr>
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<td>4</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

### Interpreting Graphs

1. **Beginning growth** The population increases, the few starting members have offspring, and the population grows.
2. **Leveling off** As the population grows, it becomes more difficult for each organism to meet its needs. Growth slows. The graph resembles the letter J.
3. **Fluctuations** The number of organisms tends to rise above and before the carrying capacity.
4. **Rapid growth** There are many organisms, each reproducing, resulting in a fast increase in the number of individuals. Growth is exponential.
5. **Carrying capacity** The environment cannot support more organisms. If population size is above the carrying capacity, organisms die.

### Figure 4.4

This bristlecone pine is an example of a long-lived species with a slow life-history pattern.
Germinating Radishes

**Purpose**
Students will study the percent of germination of radish seeds.

**Safety Precautions**
Have students wash their hands after handling the seeds.

**Materials per group**
- two petri dishes
- radish seeds
- napkins
- pipette

**Procedure**
Model the method of germination: Cut a napkin into two circles that will fit into a petri dish. Place one circle into the dish, put some seeds on top, and place the other circle on top of the seeds. Add a pipette or two of water. Cover the dish. Then give students these instructions:

1. With your group, choose one variable to change, such as the amount or type of solution used for watering. You could also investigate the effects of heat, light, or music.
2. Complete this problem statement:
   - What is the effect of __________ on the germination of a radish seed?
3. Write out your procedures before starting. Plan for a control and an experimental group.

**Analysis**
1. Why do plants produce so many seeds?
   - Not all seeds germinate.
2. Was your variable a biotic or abiotic factor?
   - Most will be abiotic factors.
3. What was your conclusion for your experiment? Answers will vary.

**Conclusion**
Students will report their results. Not all seeds germinate. Disease, for example, increases. Disease, for example, increases. Food supply, extreme temperatures, and even storms can affect population size. Ecologists have identified two kinds of limiting factors: density-dependent and density-independent factors. Density-dependent factors include disease, competition, parasites, and food. These have an increasing effect as the population increases. Disease, for example, spreads more quickly in a population with members that live close together, as indicated in Figure 4.6, than in smaller populations with members that live farther apart. In very dense populations, disease may quickly wipe out an entire population. In crops such as corn or soybeans in very dense populations, disease may quickly wipe out an entire population. In crops such as corn or soybeans, a disease can spread rapidly throughout the whole crop. In less dense populations, fewer individuals may be affected.

Density-independent factors affect all populations, regardless of their density. Most density-independent factors are abiotic factors, such as temperature, storms, floods, drought, and habitat disruption, shown in Figure 4.7. No matter how many earthworms live in a field, they will drown in a flood. It doesn’t matter if there are many or few mosquitos; a cold winter will kill them. Another example of a density-independent factor is pollution. How does pollution affect a habitat? Find out in the Chemistry Connection at the end of this chapter.

**Organism Interactions Limit Population Size**
Population sizes are limited only by abiotic factors, but also by biotic factors. Biotic factors are celled by various interactions among organisms that share a community.

**Predation affects population size**
A barn owl kills and eats a mouse. A storm of locusts eats and destroys acres of lettuce on a farm. When the brown tree snake was introduced in Guam, an island in the South Pacific, it wiped out most of the birds on the island. These examples demonstrate how predation can affect population sizes in both minor and more ways. When a predator consumes prey, it can affect the population size of the prey population. For this reason, predation may be a limiting factor of population size. Populations of predators and prey experience changes in their numbers over a period of years. Predator-prey relationships often show a cycle of population increases and decreases over time. This classic example of this has been demonstrated by graphing 90 years of data concerning the populations of the Canadian lynx and the snowshoe hare. A member of the cat family, the lynx stalks, attacks, and
can spread rapidly throughout the

**Alternative Lab**
Germinating Radishes

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- two petri dishes
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**Quick Demo**
Cut out a cardboard frame that is a little smaller than the size of the glass of the overhead projector. Put three checkers into the frame. Move the frame and cause the checkers to move about. Stop. If any checkers are within one cm of another, they die. Repeat, adding more checkers. Students will realize that the more crowded it gets, the great- er the number of checkers that die. Have them relate this to density-dependent factors.

**Visual Learning**
Ask students to study Figure 4.7.B and explain what will happen to prey populations of mice and rabbits as the predator fox population increases. The rabbit and mouse populations will decline.

**National Geographic VideoDisc**
GVG: Planetary Manager
Agriculture, Side 2

**Assessment**
Performance Assessment in the Biology Classroom, p. 53, Estimating Populations. Have students carry out the activity to show that organisms fall in a continuum between rapid life-histories and slow life-histories. These are the extremes of the scale.

**Chemistry Connection**
Find out in the Chemistry Connection at the end of this chapter.
1. Linear growth graphs form a straight line, and exponential graphs form a curved line described as J-shaped.

2. Short life-history organisms show a rapid increase and rapid decline caused by their unpredictable environments. When overcrowded, animals fight and territory can become fierce. Stress caused by overcrowding in a rat population can limit population size.

3. Density-dependent factors affect a population no matter what its size.
Doe Earth have a carrying capacity for the human population? How many people can Earth support? And is it currently possible to tell when the human population will stop growing? However, demographers suggest that food production will not always keep pace with the population increase.

### Effects of Birthrates and Death Rates

**How can you tell if a population is growing?** A population's growth rate is the difference between the birthrate and the death rate. One way of calculating a population's growth rate is by calculating its doubling rate. Learn how to calculate doubling rates in the MiniLab on this page. In many industrialized countries, such as the United States, declining death rates have a greater effect on total population growth than increasing birthrates. For example, in the United States, life expectancy increases almost every year. This means that you are more likely to live slightly longer than students who are presently in college.

Although people in the United States are living longer, the fertility rate is decreasing. This is because more people are waiting until their thirties to have children. Today's families also have fewer children than they did in previous decades. Fertility rate is the number of offspring a female produces during her reproductive years. When fertility rates are high, populations grow more rapidly unless the death rate is also high. Table 4.2 shows the birthrate, death rate, and fertility rate of some rapidly growing, slow-growing, and stable populations.

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**Interpreting Graphs**

**MiniLab 4-2**

**Using Numbers**

**Doubling Time**

The time needed for any population to double its size is known as its “doubling time.” For example, if a population grows slowly, its doubling time will be long. If it is growing rapidly, its doubling time will be short.

**Procedure**

1. The following formula is used to calculate a population’s doubling time:
   
   \[ t = \frac{\ln 2}{\text{growth rate}} \]

   **Doubling time (in years)**

   **Annual percent growth rate**

   **Doubling time**

   **Analysis**

   1. Which region has the smallest doubling time? Slowest doubling time?
   2. What might this type of information be useful to government officials in their region?
   3. What are some of the ecological implications for an area with a fast doubling rate?

---

**Portfolio** Have students prepare a bar graph using their calculated values for doubling time. Use the Performance Assessment List for Graph from Data in PASC, p. 19.

**Assessment**

**Skill:** Ask students to use Table 4.2 to identify the factors that contribute to a high population growth rate. Responses may include high birthrates, low death rates, and high fertility rates.

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**Cultural Diversity**

Suggest that there tend to be more babies per woman in economically depressed countries. Reasons might include (a) people prefer large families; (b) large families may have more prestige; and (c) religions may encourage people to have more children.

---

**Minilab 4-2** Students will learn the concept of “doubling time” and use a formula to calculate this value.

**Process Skills**

- use numbers, acquire information, analyze information, compare and contrast, predict, recognize cause and effect

**Teaching Strategies**

- Organize the class into small groups
- Place students with poorer math skills with those who are more skilled.
- Allow students to use calculators

**Expected Results**

- Africa > 25 years, Latin America = 31.8 years, Asia = 36.8 years, N. America = 100 years, Europe = 233 years

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**Assessment**

1. Africa; Europe
2. Answers may vary, but students may mention the planning of roads, homes, and other needed structures.
3. Students may list the high potential for disease, problem with waste disposal, and lack of space.

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**Analysis**

1. Why did the population of Paramecium increase?
2. How many paramecia would be produced in 30 hours?
3. Assuming the birthrate remains constant, how many paramecia would be present if one paramecium died during each six-hour period?

---

**Prepare**

- Purchase beans, markers, and bags for the BioLab.

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**Section 4.2 Human Population Growth**

**Objectives**

- List population characteristics to populate growth rates.
- Compare the age structure of rapidly growing, slow-growing, and non-growth countries.
- Hypothesize about problems that can be caused by immigration and emigration.

**Vocabulary**

- demography
- age structure
- immigration
- emigration

---

1. **Bellringer**

Before presenting the lesson, display Section Focus Transparency 9 on the overhead projector and have the students answer the accompanying questions.

---

**Section Preview**

- Modern population growth rates are accelerating to unprecedented levels.
- Population growth rates are determined by birthrates and death rates.

---

**Population Biology**

- Immigration
- Age structure
- Vocabulary

---

**Questions That Can Be Asked**

- How do you know when a population has reached its limiting capacity?
- How do demographers determine the carrying capacity of the environment?
- How do limits to population growth factors that determine the carrying capacity of the environment differ from predator-prey interactions or overcrowding?

---

**Figure 4.10**

- Ten thousand years ago, approximately 10 million people inhabited Earth. Today, there are more than 6 billion, and scientists estimate that by the year 2050, there will be more than 10 billion people on Earth.

---

**Demographic Trends**

- A good way to predict the future of the human population is to look at past population trends. For example, are there observable patterns in the growth of populations? That is, are there any similarities among the population growths of different countries—similarities that might help scientists predict, and therefore control, future population catastrophes?

---

**Change in the Human Population Over Time**

- Graph showing the percentage increase in the human population from 1980 to 2050.

---

**Table 4.2 Birthrates and death rates around the world**

<table>
<thead>
<tr>
<th>Region</th>
<th>Birthrate (per 1000)</th>
<th>Death Rate (per 1000)</th>
<th>Fertility (per woman)</th>
<th>Population Increase (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Growth Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>38.8</td>
<td>5.5</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Uganda</td>
<td>52.8</td>
<td>7.1</td>
<td>3.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>39.3</td>
<td>5.4</td>
<td>3.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Slow Growth Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>9.6</td>
<td>10.8</td>
<td>1.2</td>
<td>-1.5</td>
</tr>
<tr>
<td>Italy</td>
<td>9.4</td>
<td>9.7</td>
<td>1.2</td>
<td>-6.5</td>
</tr>
<tr>
<td>Sweden</td>
<td>10.8</td>
<td>10.6</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>North American Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>27.0</td>
<td>5.2</td>
<td>3.1</td>
<td>2.2</td>
</tr>
<tr>
<td>United States</td>
<td>14.0</td>
<td>8.8</td>
<td>2.0</td>
<td>0.6</td>
</tr>
</tbody>
</table>

---

**MiniLab 4-2**

**Using Numbers**

**Doubling Time**

The time needed for any population to double its size is known as its “doubling time.” For example, if a population grows slowly, its doubling time will be long. If it is growing rapidly, its doubling time will be short.

**Procedure**

1. The following formula is used to calculate a population’s doubling time:
   
   \[ t = \frac{\ln 2}{\text{growth rate}} \]

   **Doubling time (in years)**

   **Annual percent growth rate**

   **Doubling time**

   **Analysis**

   1. Which region has the smallest doubling time? Slowest doubling time?
   2. What might this type of information be useful to government officials in their region?
   3. What are some of the ecological implications for an area with a fast doubling rate?

---

**Portfolio** Have students prepare a bar graph using their calculated values for doubling time. Use the Performance Assessment List for Graph from Data in PASC, p. 19.

**Assessment**

**Skill:** Ask students to use Table 4.2 to identify the factors that contribute to a high population growth rate. Responses may include high birthrates, low death rates, and high fertility rates.

---

**Cultural Diversity**

Suggest that there tend to be more babies per woman in economically depressed countries. Reasons might include (a) people prefer large families; (b) large families may have more prestige; and (c) religions may encourage people to have more children.
Determine the human population’s doubling time as it increases from half a billion to one billion, from one to two billion, and from two to four billion.

Explain the significance of the trend shown in question 4. Explain why.

Using the values for doubling time provided in question 4, calculate the human population’s annual percent growth rate using the method described in the MiniLab on the previous page. Use the formula below:

Doubling time (in years) = \[ \frac{70}{\text{Annual percent growth rate}} \]

Explain the significance of the trend shown by your answer to question 6.

To review the meaning of density-dependent factors, carrying capacity, and age structure, see the previous page. Use the Performance Assessment List on this page.

Using the age structure graph for the United States in Figure 4.17, explain which gender has a higher life expectancy and then suggest a hypothesis for why this difference exists.

Understanding Main Ideas
1. What characteristics of locations do demographers study?
2. How does life expectancy affect death rate?
3. What clues can an age structure graph provide about a country’s population growth?
4. Discuss some possible problems for local populations caused by immigration and emigration of workers.

Thinking Critically
5. Using the age structure graph for the United States in Figure 4.17, explain which gender has a higher life expectancy and then suggest a hypothesis for why this difference exists.

Application

Applying Concepts

What trends are seen in the human population? Human population trends present some interesting ideas and concepts. Because of our intelligence, we are better able to control our population size, regulate our food supply, and remove waste products from our environment. Thus, human population trends may differ from those of other organisms.

Analysis

Figure 4.10 shows human population changes over time. Study this graph and answer the questions below.

Thinking Critically
1. What density-dependent factors can influence human population growth? What density-independent factors can influence human population growth?
2. Has the human population reached its carrying capacity? Explain why.
3. Based on the graph in Figure 4.10, what will be Earth’s population in the year 2015?
4. Determine the human population’s doubling time as it increases from half a billion to one billion, from one to two billion, and from two to four billion.
5. Explain the significance of the trend shown in question 4.
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Thinking Critically
5. Using the age structure graph for the United States in Figure 4.17, explain which gender has a higher life expectancy and then suggest a hypothesis for why this difference exists.
Problem
How can you model a measuring technique to determine the size of an animal population?

Objectives
In this BioLab, you will:
- Model the procedure used to measure an animal population.
- Collect data on a modeled animal population.
- Calculate the size of a modeled animal population.

Materials
paper bag containing beans
magic marker
calculator (optional)

Safety Precautions
Always wear goggles in the lab.
Wash hands after working with plant material.

Skill Handbook
Use the Skill Handbook if you need additional help with this lab.

PREPARATION
1. Copy the data table.
2. Reach into your bag and remove 20 beans.
3. Use a dark magic marker to color those beans. Those will represent your caught and marked animals.
4. When the ink has dried, return the beans to the bag.
5. Shake the bag. Without looking into the bag, reach in and remove 20 beans.
6. Record the number of marked beans (recaught and marked) and the number of unmarked beans (caught and unmarked) in your data table as trial 1.
7. Repeat step 4 for trials 2 to 5.
8. Calculate averages of each of the columns.
9. Using average values, calculate the original size of the bean population in the bag by using the following formula:
   \[ \text{Population Size} = \frac{\text{Total beans}}{\text{Average caught}} \times \text{Average unmarked} \]

PROCEDURE
1. Thinking Critically This experiment is a simulation. Explain why this type of activity is best done as a simulation.
2. Applying Concepts Give an example of how this technique could actually be used by a scientist.
3. Analyzing Data Compare the calculated to the actual population size. Explain why they may not agree exactly. What changes to the procedure would improve the accuracy of the activity?
4. Making Inferences Explain why this technique is used more often with animals than with plants.

ANALYZE AND CONCLUDE
1. Thinking Critically This experiment is a simulation. Explain why this type of activity is best done as a simulation.
2. Applying Concepts Give an example of how this technique could actually be used by a scientist.
3. Analyzing Data Compare the calculated to the actual population size. Explain why they may not agree exactly. What changes to the procedure would improve the accuracy of the activity?
4. Making Inferences Explain why this technique is used more often with animals than with plants.

Going Further
Writing about Biology
Assume that you are a field biologist on Mackinaw Island, Michigan. Explain in detail how you would go about determining the deer population on the island. Include a data table that could be used in your procedure.

HUMAN POPULATION GROWTH

4.2 HUMAN POPULATION GROWTH

CALCULATING AVERAGE

Data Table

<table>
<thead>
<tr>
<th>Trial</th>
<th>Total caught</th>
<th>Number caught with marks</th>
<th>Number caught without marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>30</strong></td>
<td><strong>12</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

Calculated population size = \( \frac{150}{8} = 18.75 \)

Actual population size = \( \frac{150}{12} = 12.5 \)

(This number will vary per bag.)
Polystyrene: Friend or Foe?

Polystyrene is a synthetic plastic derived from the monomer styrene. Pure polystyrene is brittle, but by combining styrene with other monomers, a high-impact-resistant plastic is formed. Polystyrene is commonly used to build insulation and flotation devices, as packaging materials, and to make a wide assortment of disposable cups, plates, bowls, containers, and cutlery.

Polystyrene products

- Foam beverage cups and plates, plastic forks, some packaging “peanuts,” and the jewel cases that house compact discs are made using pentane or carbon dioxide as the blowing agent. Unlike CFCs, these gases do not destroy Earth’s ozone layer.
- Polystyrene makes up less than 1 percent of our waste.

The perils of polystyrene

Despite its convenience and popularity in various industries, polystyrene poses some environmental concerns. The main monomer in this plastic—styrene—is classified as a neurotoxin, as it impairs the central and peripheral nervous systems. Long-term exposure to even small amounts of styrene can also cause abnormal blood clotting, brain disorders, and cancers.


d. Drought

e. Evolutionary growth

Summary

- Populations may exhibit slow growth that tends to be density independent. Populations might increase in a decade or a year, or remain relatively stable. Populations of organisms in ideal conditions and populations of organisms in less favorable conditions may exhibit intermediate growth patterns.
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Chapter 4 Assessment

Main Ideas

- Some populations grow exponentially until they reach the carrying capacity of the environment.
- Populations may exhibit slow growth that tends to be density independent. Populations might increase in a decade or a year, or remain relatively stable. Populations of organisms in ideal conditions and populations of organisms in less favorable conditions may exhibit intermediate growth patterns.

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- Populations may exhibit slow growth that tends to be density independent. Populations might increase in a decade or a year, or remain relatively stable. Populations of organisms in ideal conditions and populations of organisms in less favorable conditions may exhibit intermediate growth patterns.
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Vocabulary

- Density-dependent factors such as disease and food supply, and density-independent factors such as weather, have effects on population size. Interactions among organisms such as predation, competition, stress, and crowding also limit population size.

Endnotes

1. Between A.D. 1 and A.D. 1650, the world’s population had a major drop because of bubonic plague.
2. d.
3. c.
4. a.
5. c.
6. b.

5. Which of the following environments would be more likely to have organisms that exhibit fast growth?

4. a. Hot deserts
5. b. Tropical rain forests
6. c. Boreal forests
7. d. Temperate forests
8. e. Tropical deserts

All Chapter assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.

Understanding Main Ideas

1. Which of the following factors is density-independent?
   - a. Fertility
   - d. Food
   - c. Wind speed
   - b. Intrinsic growth rate

2. When populations increase, resource depletion may result in:
   - a. Evolutionary growth
   - b. Straight-line growth
   - c. Competition
   - d. Increase in predators

3. Storms, cold temperatures, and drought are all:
   - a. Density dependent
   - b. Biotic factors
   - c. Exponential
   - d. Density independent

4. A female’s fertility rate is the number of offspring she produces in a year.

MindJogger Videoquizzes

Chapter 4 Population Biology

Have students work in groups as they play the videoquiz game to review key chapter concepts.

MindJogger Videoquizzes

Chapter 4: Population Biology

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet to track the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web site. science.glencoe.com

MindJogger Videoquizzes

Chapter 4 Assessment

Main Ideas

- Some populations grow exponentially until they reach the carrying capacity of the environment. Populations may exhibit slow growth that tends to be density independent. Populations might increase in a decade or a year, or remain relatively stable. Populations of organisms in ideal conditions and populations of organisms in less favorable conditions may exhibit intermediate growth patterns.

Summary

- Populations may exhibit slow growth that tends to be density independent. Populations might increase in a decade or a year, or remain relatively stable. Populations of organisms in ideal conditions and populations of organisms in less favorable conditions may exhibit intermediate growth patterns.

Vocabulary

- Density-dependent factors such as disease and food supply, and density-independent factors such as weather, have effects on population size. Interactions among organisms such as predation, competition, stress, and crowding also limit population size.

Connecting to Biology

Many environmentalists in this nation, as well as people in other Western cultures, view Americans as a “throw-away” society based on single-use plastics. The advantage is that this material takes up valuable space in landfills.
7. According to the graph, the growth rate of a house fly population is _______.

a. increases, then drops suddenly
b. increases, at a steady rate
c. increases rapidly
d. levels off after a certain amount of time

8. A person breeds rabbits in a cage. After a few generations, she observes that the rabbits are more aggressive towards each other, the young are less healthy, and more young rabbits die. This population is:

a. under stress
b. under the carrying capacity
c. density independent
d. both choices a and c

9. A life-history pattern that tends to approach carrying capacity with minor fluctuations is:

a. population dependent
b. slow growth
c. fast growth
d. regulated by most insects

10. What can be said about the growth of a country with an age structure graph that approximates a rectangle?

a. It is decreasing.
b. It is increasing slowly.
c. It is stable.
d. It is increasing rapidly.

11. A J-shaped growth curve indicates a population is experiencing _______.

12. The highest level at which a population can be sustained is its _______.

13. Population growth rates are affected by _______ and _______.

14. Predators that help control the size of a population represent a _______ _______.

15. From Table 4.2, the fastest growing country is _______. The woman of _______ gives birth to the most children.

16. The solid-line graph below shows the changes in deer population over time. The dotted line represents the _______ and _______ rates. It is also influenced by immigration and _______.

17. A person who studies human population growth characteristics is a _______.

18. A bacterial cell divides every 30 minutes and produces two cells. Starting with one cell, after 10 minutes there would be two cells, after 60 minutes _______ cells, and after 90 minutes, _______ cells.

19. A demographic estimate of how long a person of a particular age will live is called his/her _______. In the United States, this estimate _______ every year.

20. Populations that grow without restriction are _______.

21. Which environmental factors would most affect the populations of developing countries?

22. As human populations grow, what might happen to the populations of other species? Discuss the causes for your hypotheses.

23. Assume that a female black rat gives birth every month and produces eight young. In each litter, four are female and four are male. Starting in month zero with one newborn litter of four males and four females for a total population of eight, calculate the total population size at months 1, 2, and 11.

24. Observing and Inferring Why are short life-history species, such as mosquitos and some weeds, successful even though they often experience massive population declines?

25. Comparing and Contrasting Compare and contrast the characteristics of species having long-life-history patterns with those that have short-life-history patterns.

26. Concept Mapping Complete the concept map by using the following vocabulary terms: density-dependent factors, density-independent factors, exponential growth, immigration.

27. Density-dependent factors such as limited food or water and increased chances for disease to spread

28. The populations of other species may decrease. Humans may disrupt the habitats of other species, so that they do not have enough space for maturing, rearing offspring, or finding shelter and food.

29. Month one = _______ parents + _______ females times _______ offspring = _______. Month two = _______ parents + _______ females times _______ offspring = _______. Month three = _______ parents + _______ females times _______ offspring = _______.

30. Thinks Critically Why are short life-history species more likely to spread weeds, successful even though they often produce massive population declines?

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