Chapter 3

Population

An ecosystem is made up of many components and their interactions. When examining at the species in a given location, assessing the populations of that species gives important information about the structure, growth, and potential decline of that species. Many of these characteristics and structures can apply to the human population as well, but humans are unique and, therefore, also have distinctive population dynamics. In this chapter, the basic concepts of population dynamics are reviewed, followed by a more detailed look at the human population.

Population Biology Concepts

A **population** is a group of individuals of the same species living in a particular area at the same time. The size of a population is dependent upon four factors:

- Birth rates in a population (also called **natality**)
- Death rates in a population (also called **mortality**)
- Immigration of organisms into one population from another population
- Emigration of organisms leaving a population

Population Ecology

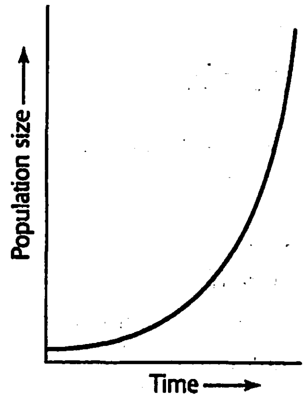
Population ecology is the study of how individuals within a population interact with one another. Populations of organisms are described based on characteristics that help to better understand that population and to predict what might happen in the future. Characteristics include:

- **Population size:** The number of individuals in a population at a given time. Over time, the size of a population of organisms can change, remain the same, or go through cycles of increasing and decreasing numbers.
- **Population distribution:** The spatial arrangement of organisms in an area. This can be explained as:
  - **Random distribution:** With random distribution, organisms are spaced arbitrarily, with no organization or intention, as with free-floating larvae in the ocean. This is the least common arrangement in nature.
  - **Uniform distribution:** Uniform distribution occurs when organisms are spaced evenly from one another. This occurs due to necessity, such as limited resources making distance necessary for survival of organisms that are territorial. Wolves are one example of a species with uniform distribution because they are territorial animals.
  - **Clumped distribution:** The most common in nature, clumped distribution occurs because organisms often gather around a necessary resource. Animals that live in herds demonstrate clumped distribution, such as buffalo.
- **Population density:** The number of individuals in a population per unit area. Usually more resources and a larger area are necessary for species that are larger in size, whereas smaller organisms don't need as much space or as many resources. With any organism, high population density could lead to increased competition for resources and an increased chance of the transfer of disease, but it also betters the chances of mating. Lower population densities decrease the chance of competition and the spread of disease but may also make it more difficult to find a mate.
- **Age structure:** Examines the number of organisms in each age range within a population. This distribution will affect whether a population grows, declines, or remains stable over time. If most individuals are younger, the population will most likely increase in number. When a population is comprised mostly of older individuals past reproductive age, the population will probably decline. Even age distribution reflects a stable population. The age structure of a population is shown in age-structure diagrams or age pyramids.
- **Sex ratio:** The number of males to females in a population. This can affect whether a population of organisms will increase or decrease over time because it affects the chances of mating.

Carrying Capacity

Given the right situation and enough resources, a population can grow. In **exponential growth,** a population increases by a fixed percentage per unit of time. Exponential growth is represented on an exponential growth curve (see the following figure). A population can grow exponentially when it's using an unused resource or colonizing a new environment. Exponential growth cannot last indefinitely, though, because resources are finite. Humans are an example of a population that has experienced exponential growth. The question is, when will our resources run out?

Exponential Growth Curve



Because resource availability will eventually decrease, exponential growth will be halted when a population reaches **carrying capacity (K).** This is the maximum number of organisms in a species that an environment can support indefinitely. Carrying capacity is not a set number and can vary depending on the environment, populations, and limiting factors.

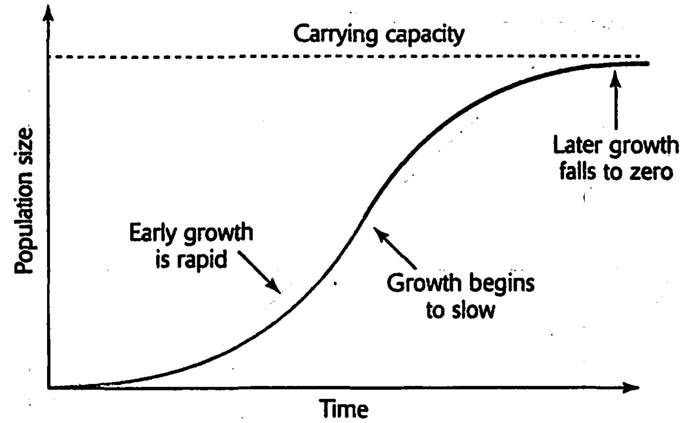
A population reaches its carrying capacity based on **limiting factors,** which are the factors that control a population's growth. Limiting factors can be the availability of food, shelter, water, mates, or anything else an organism depends upon for survival. A population can also be limited by disease, predators, natural disasters, sunlight, moisture, temperature, or nutrients. And in an aquatic ecosystem, salinity, sunlight, pollutants, dissolved oxygen, or temperature can play a role in restricting population growth. All limiting factors acting on a population together are called **environmental resistance.** Sometimes a species can alter its environment, thus increasing its carrying capacity and decreasing its environmental resistance. Humans are an example of a species that has created ways of bettering survival through alteration of the environment and through invention.

Some limiting factors are related to the density of a population. These factors are considered **density-dependent factors** and include disease, availability of mates, and predation. A population that is denser is at an increased risk of predation or the transmission of disease, yet it has a higher probability of finding mates. On the other hand, **density-independent factors** do not depend on the density of a population. For example, natural disasters, extreme temperature fluctuations, or lack of sunlight can affect the numbers of a species, regardless of whether the organisms are in a crowded population.

In order to represent a population that grows exponentially and then reaches its carrying capacity, a **logistic growth curve** (see the following figure) is used. Initially, a population increases quickly; then it levels off due to limiting factors. The logistic growth curve is generally a theoretical model because actual populations of organisms don't behave as the curve suggests. Different populations act in a variety of ways depending on the environment, the species, and limiting factors. More realistic logistic growth curves show populations that:

- Fluctuate above and below carrying capacity for an indefinite amount of time
- Rise quickly and then decrease abruptly
- Fluctuate for a period of time, and then start to experience less dramatic changes and stabilize to an extent
- Exhibits a pattern similar to the theoretical model

Logistic Growth Curve



Reproductive Strategies

Limiting factors affect a population's growth and decline, along with an organism's **biotic potential,** the ability of an organism to produce offspring. There are two types of reproductive strategies:

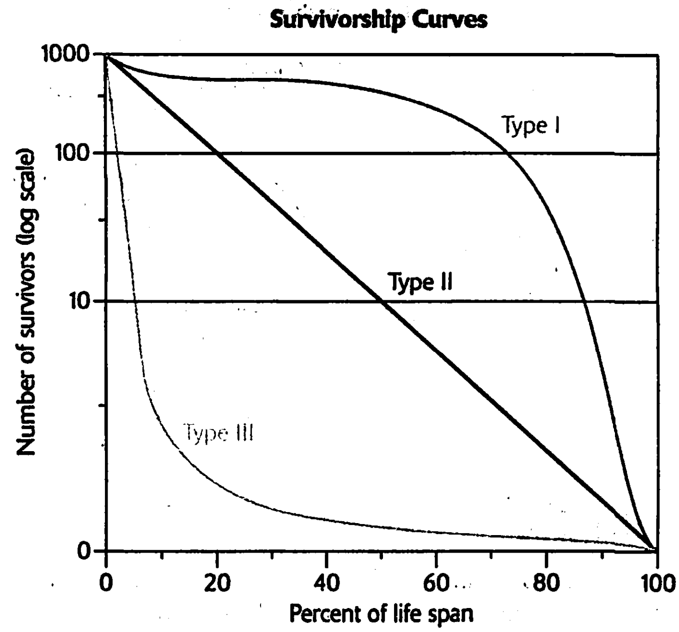
- **K-selected:** K-selected species are species that have relatively few offspring and devote a large amount of time, energy, and resources toward nurturing and raising their young. These organisms usually are larger, have long gestation periods, and live longer. Because only a few offspring are produced, k-selected species have low biotic potential. Overall, these populations also remain close to carrying capacity and have a relatively constant population size. Examples include humans, elephants, horses, and cows.
- **R-selected:** R-selected species are small organisms that have short gestation periods and produce thousands of offspring at one time; therefore, they have high biotic potential. Energy and resources are put into producing many offspring and not into raising the young. This strategy means that the young are left to their own survival, and survival depends on chance. R-selected species are short-lived and have population sizes that vary, usually not remaining near carrying capacity but well below it. Examples include spiders, fish, and frogs.

Not all species fit into one of these two strategies. Some organisms fall in between.

Survivorship

Survivorship curves (like the one shown on the next page) represent the number of individuals surviving at each age for a given species. The *y*-axis shows the number of individuals and the *x*-axis reflects time or age. The three types of survivorship curves are

- **Type I:** Organisms that reproduce at a relatively young age, have a small number of deaths at young ages, have a long lifespan, and experience mortality mostly at an older age. Examples include humans and most large mammals.
- **Type II:** Organisms that mature quickly and have even mortality rates at all ages. Examples include rodents, many reptiles, and most birds.
- **Type III:** Organisms that have many offspring, and reproduce often. Many individuals die at an early age, and there is less mortality later in life. Examples include sea turtles, parasites, and most insects.



Human Population

The human population is unique compared to other species due to our ability to alter our environment effectively and efficiently with the use of technology and invention. Although population growth has begun to stabilize or decline in some countries, it continues to soar in others. Overall, the human population continues to grow exponentially, and since we can alter our environment to suit our needs, we have extended the carrying capacity of our planet for ourselves, while reducing the carrying capacity for other species.

Human Population Dynamics

Historical Considerations

Through most of human history, the Earth was not overpopulated and held only a few million people at any given time. As humans became more advanced and began to invent more efficient ways of doing day-to-day tasks and a safer way of life evolved, the population gradually and steadily increased. Two key events are responsible for this change:

- The **Agricultural Revolution** began about 10,000 years ago, and people started to grow crops and raise livestock. This meant that a nomadic lifestyle was no longer necessary, and it was easier to get essential nutrients to survive. People began to have more children and live longer lives.
- In the 1700s, the **Industrial Revolution** began. Life started to become more urban. Most people lived in and near cities, sanitation and medical care improved, and manufacturing became prevalent. The use of fossil fuels as an energy source sparked this new way of life and made it possible for manufacturing, production, and transportation to be more efficient. Improvements in sanitation and healthcare increased longevity, so people were living longer as well.

Currently, there are more than 6.9 billion people living on Earth, and the number is still growing exponentially. Since 1967, the human population has doubled, with over 80 million people being added every year.

Distribution

Population growth is not the same in every country or every region. Currently, growth is slowing in developed nations, while many developing countries are still growing at an astounding rate.

Studying the statistical change in human populations and applying the concepts of population ecology to this is called **demography**. By studying the size, density, distribution, sex ratios, age structure, birth and death rates, and movement of people, a demographer can help to predict shifts in populations and potential environmental consequences throughout the world.

The distribution of the human population is considered to be clumped, with more people living in regions with climates that are tropical, subtropical, or temperate. Such locations include China, India, Europe, and Mexico. Populations are also the densest near water, whether freshwater or saltwater. More people living in a particular area means there is more of an impact on the environment from use and pollution in that area.

Today, China has the world's largest population, with about 1.3 billion people; India is close behind, with 1.15 billion people; and the United States comes in third with about 300 million people. China and India still are considered developing nations but are quickly catching up to developed countries due to increased job growth and opportunities. The environmental impact of both countries is already large, but with more and more people having the means to consume and the desire to live lifestyles based on consumerism, the effect on the environment will be even more dramatic and humans will move even closer to reaching carrying capacity on the planet.

The IPAT Model

As a way to look at the human impact on the environment, in 1974 Paul Ehrlich and John Holdren developed the **IPAT model,** which examines how technology, affluence, and population all work together to impact the environment. It's shown as $I = P \times A \times T$, where

- I stands for the impact on the environment.
- P stands for population. Population can affect the environment because more people mean more land and resources are used and more waste is produced.
- A stands for affluence. Greater affluence means larger resource consumption per person due to increased wealth.
- T stands for technology. Technology can act positively or negatively either by creating ways to exploit resources faster and more easily, or by developing better ways to reduce our impact, such as better pollution controls or renewable energy.

Sensitivity can also be added to the IPAT model, taking into account the sensitivity of an environment when being used by humans. For example, deserts and grasslands are more susceptible to degradation if they are not managed properly.

The Rule of 70

Overall, a population's net change in size, per 1,000 individuals, is measured by its **growth rate**, which is calculated as follows:

$$\text{Growth Rate} = (\text{Birth Rate} + \text{Immigration}) - (\text{Death Rate} + \text{Emigration})$$

For example, if the birth rate is 10 individuals, immigration is 20 individuals, the death rate is 15 individuals, and emigration is 5 individuals, it would be calculated as follows:

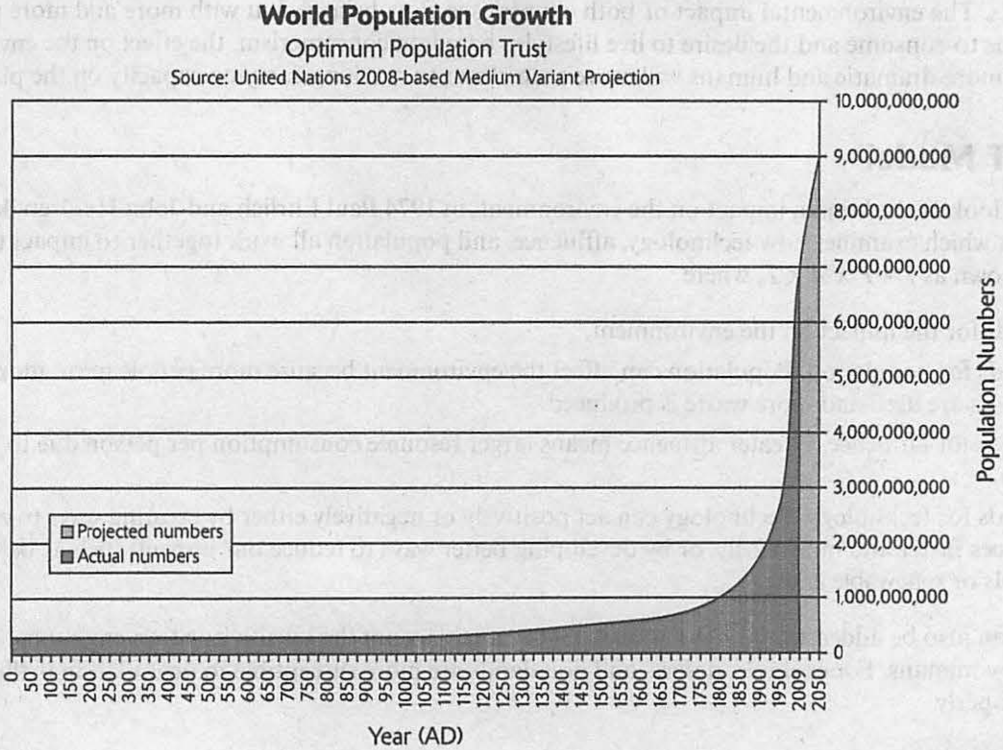
$$(10 + 20) - (15 + 5) = 30 - 20 = 10 \text{ per 1,000 individuals}$$

This means that the population will grow by 10, so in one year the population will add 10 individuals per 1,000 individuals. Expressed as a percentage, the growth rate is

$$10 \text{ per } 1{,}000 \times 100 \text{ percent} = 1 \text{ percent annually}$$

As mentioned earlier, with exponential growth, a population grows by a fixed percentage each year. Therefore, although the population of 1,000 individuals grew by 10 in one year, if that same 1 percent growth rate continues each year, the population grows by 1 percent each year. For example, a population of 1,000 mice that grows at a rate of 1 percent each year will end up at 1,010 mice after one year. Although this doesn't sound like a large increase in population, due to exponential growth, the population will grow to 1,100 after ten years if it remains at a 1 percent growth rate. Look at this on a larger scale, such as with a population of 1 million individuals, and it is evident how quickly a population can multiply and grow.

The human growth rate was at its highest in the 1960s at 2.1 percent. Since then, it has dropped to 1.2 percent, but this rate still reflects growth, so the human population continues to grow exponentially. In the early 1800s, the human population was close to 1 billion people; in 1950 the human population was approximately 2.5 billion; and in 2005 humans totaled about 6.5 billion. By 2050, the human population could reach over 9 billion.



Source: Population Matters

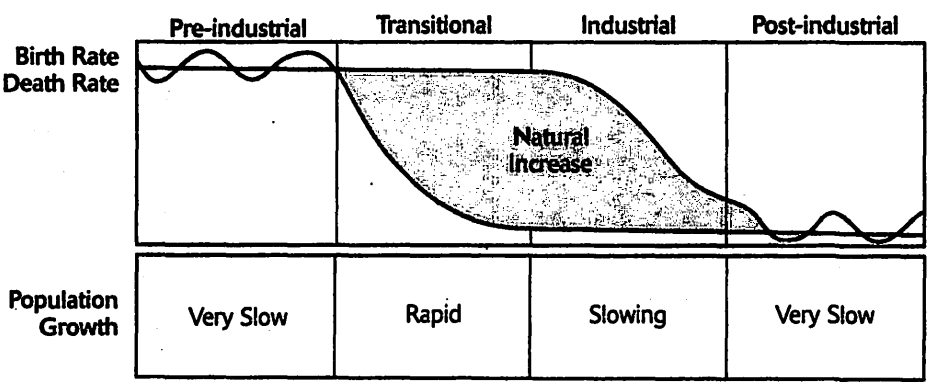
Doubling time is the amount of time it takes for a population to double. It is also called the Rule of 70, because to find doubling time, 70 is divided by the annual percentage growth rate of a population. For example, a population with a 3 percent growth rate will double in a little over 23 years ($70 \div 3 = 23.3$).

Demographic Transition

As the Western world has become more and more industrialized, there have been many shifts in birth and death rates. In order to explain this, a model was developed by Frank Notestein in the 1940s and 1950s called **demographic transition.** Demographic transition moves from a pre-industrial stage, to a transitional stage, to an industrial stage, and ends in a post-industrial stage. Not all nations have or will pass through this demographic transition; it's dependent on cultural and economic structures of each nation.

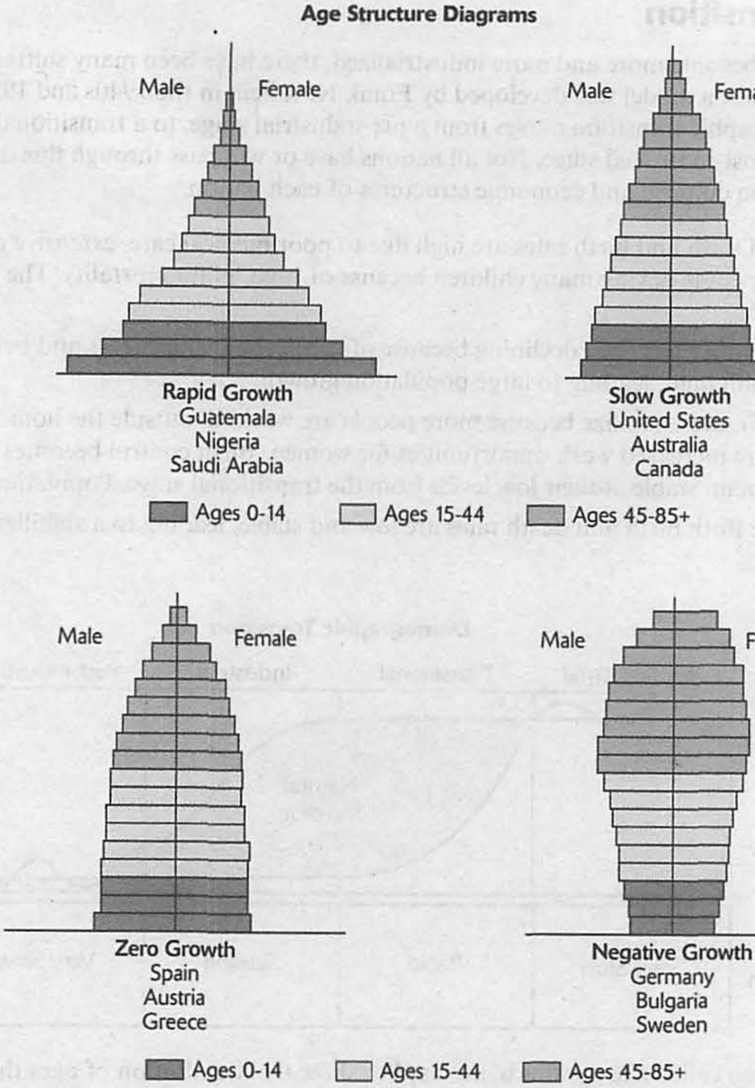
- **Pre-industrial stage:** Death and birth rates are high due to poor medical care, extensive disease, difficulty in acquiring food, and people having many children because of high infant mortality. The population of people is relatively stable.
- **Transitional stage:** Death rates start declining because of medical advancements and better food production. Birth rates remain high, leading to large population growth.
- **Industrial stage:** Birth rates stabilize because more people are working outside the home as opposed to farming, and there are increased work opportunities for women. Birth control becomes more commonly used. Death rates remain stable at their low levels from the transitional stage. Population growth slows.
- **Post-industrial stage:** Both birth and death rates are low and stable, leading to a stabilization or small decline in population.

Demographic Transition



Age structure diagrams, also called age pyramids, are used to show the distribution of ages throughout a population and can help to forecast what might happen to a population over time. There are three general structures with some variation depending on the changes within a population:

- A balanced age structure generally has the same number of individuals throughout each age group and represents a stable population and no growth. Examples include Denmark, Austria, and Spain.
- A pyramid-shaped diagram reflects a population with a large number of young people. This is a growing population, and in the long term this population will increase assuming no major changes to any particular group. A pyramid can represent either rapid growth or slow growth. Examples of rapid growth (a steep-sided pyramid) include Afghanistan, Angola, Kenya, Nigeria, and Guatemala. Examples of slow growth (a gently sloping pyramid) include the United States and Canada.
- An inverted pyramid structure, or diamond-shaped structure, shows an aging population with fewer young. This population will decline over time, but it may put pressure on the young to take care of the elderly. Also, there could be a decline in the economy and in the strength of that nation's military, with fewer young entering the workforce. Examples include China and Germany.



Source: U.S. Census Bureau

Population Size

For most of human history, the total population has been relatively small. In 1804, the human population was 1 billion; today, it's more than 6.9 billion. Many changes in human society worked together to create the dramatic increase in world population in just over 200 years.

The initial human population is thought to have been stable at approximately 1 million because, at that time, humans were mainly hunters and gatherers, a lifestyle that ensured a low population. With the agricultural revolution about 10,000 years ago, humans began to transition from hunting and gathering food to growing their own food. Studies have shown that in seven or eight locations around the world, agriculture developed independently. The nomadic human society of hunters and gatherers was changed into a sedentary society, which led to the development of villages and small towns. As societies grew and developed, they altered the lands they used to grow their crops, and they selected crops that would increase production, longevity, and other beneficial features. The availability of more food and access to it year-round helped push the population to nearly a billion at the beginning of the Industrial Revolution. By far, the larger populations were in agriculturally developed countries compared to societies that continued to hunt and gather.

As harvests began to supply a surplus, fewer people had to grow crops, which led to specialization of tasks, such as the development of the blacksmith, baker, shoemaker, and many more trades. The development of the arts and music as we know them today can be credited to the specialization brought about by the changes in society during the agricultural revolution.

A look through human history shows many periods of dramatic decline in human population. These declines can be attributed to more densely populated societies living in villages and towns. Diseases spread easily and were more difficult to isolate with higher numbers of people living closely together. One notable period in world and European history was the Black Death pandemic of the 14th century, when the estimated world population of 450 million was reduced to between 350 million and 375 million. Approximately 200 years passed before Europe regained its 1300 population level.

At the beginning of the Industrial Revolution, the human population began to climb. One cause was a drop in infant mortality rates from roughly 75 percent in the 1730s to 32 percent in the 1820s. Then, in the later 1800s, with the development of an understanding of the transmission of diseases and improvements in medical practices, dental care, and food pasteurization, a dramatic reduction in death rates affected all age levels. The population of the world began to grow rapidly. The following table shows the historic human population from 1804 to the present with estimates for the future as well.

Population									
	1 billion	2 billion	3 billion	4 billion	5 billion	6 billion	7 billion (estimated)	8 billion (estimated)	9 billion (estimated)
Year	1804	1927	1960	1974	1987	1999	2011	2025	2050
Years elapsed		123	33	14	13	12	12	14	25

Based on a 2010 list maintained by the United Nations (UN), the world has 230 countries, 38 of which are identified as developed. The remaining countries are considered to be developing. The ten most populated countries include China, with the greatest population; India, close behind at number two; and the United States, a distant third. Of the ten countries with the largest populations, only three—the United States, Russia, and Japan—are completely developed. China is fast becoming a developed country.

The world growth rate is 1.17 percent, but many of the poorest countries have rates higher than 2 percent. Fifty-two countries have a growth rate higher than 2 percent. Seventy-five countries are experiencing a growth rate between 0 percent and 1 percent. A 0 percent growth rate means the particular population is not growing, and a 1 percent rate means the population will double in 70 years, based on the Rule of 70. A growth rate of less than zero means the population is declining. The world has 25 countries with a negative growth rate.

The Ten World's Largest Human Populations				
Rank	Country	Population	Year	Growth Rate (Percent)
1	China*	1,338,820,000	2010	0.58
2	India	1,183,600,000	2010	1.46
3	United States	309,810,000	2010	0.97
4	Indonesia	231,369,500	2010	1.16
5	Brazil	193,243,000	2010	1.26
6	Pakistan	170,090,000	2010	1.84
7	Bangladesh	162,221,000	2009	1.67
8	Nigeria	154,729,000	2009	2.27
9	Russia	141,927,297	2010	−0.47
10	Japan	127,530,000	2009	−0.19
	World	6,901,490.881	2010	1.17

* China is the People's Republic of China and excludes the special administrative regions of Hong Kong and Macau as well as the islands of Taiwan.

Source: United Nations 2005–2010

Exactly what defines *developed* and *developing* countries depends greatly on the listing organization. No set criteria exist for listing a country as developed or developing; they vary from one organization to the next. One former UN Secretary General describes developed countries as nations that allow their citizens to enjoy a free and healthy life in a safe environment. Other organizations focus on income levels, access to safe drinking water, medical care, and jobs. The following list of developed countries is based on the United Nations list.

Middle East

1. Israel
2. Kuwait
3. Qatar
4. United Arab Emirates

Asia

5. Brunei
6. Hong Kong
7. Japan
8. Singapore
9. South Korea

Australia

10. Australia

Europe

11. Andorra
12. Austria
13. Belgium
14. Czech Republic
15. Denmark
16. Finland
17. France
18. Germany
19. Greece
20. Iceland
21. Ireland
22. Italy
23. Liechtenstein
24. Luxembourg
25. Malta
26. Netherlands
27. Norway
28. Portugal
29. Slovenia
30. Spain
31. Sweden
32. Switzerland
33. United Kingdom

North America

34. Canada
35. United States

Other

36. Barbados (Caribbean island)
37. Cyprus (Eurasian)
38. New Zealand (South Pacific island)

Population Sustainability

Exactly what is meant by population sustainability? Does it mean that the population will remain the same (zero growth rate), grow rapidly, grow slowly or decline? Will the world's population exceed the carrying capacity of Earth, or has it already exceeded the carrying capacity?

Population sustainability refers to these types of questions; scientists and their governing institutions continue to seek answers for them. Understanding the complex interactions between Earth's population and the amount of its resources used is a difficult task. There are organizations that believe that humankind has exceeded the carrying capacity of Earth and that the number of existing human organisms in the world cannot be supported by the given sustainability on Earth. In addition, there is a growing concern among ecologists who suggest that the total population must be lowered to support sustainability.

The continued research and study of population sustainability recognizes the importance of the preservation of human-valued natural resources (land, air, and water) to sustain the population and preserve quality of life for future generations. There is no way to measure whether global population has reached the carrying capacity of Earth, or if there are sufficient renewable resources to support the number of living organisms for future generations. What we do know is that over 6 million children die every year from preventable or treatable diseases, nearly 1 billion people do not have access to clean water, nearly 1 billion people are malnourished, and 96 percent of the population growth between 2005 and 2050 will occur in the developing countries. In addition, sub-Saharan Africa has high levels of HIV/AIDS—as high as 50 percent in some regions. Other issues that affect population growth include religion, the availability of family planning, education, income, attitudes toward birth control, the role of women, and cultural norms.

Population Policies

In order to slow population growth, many countries have established policies and programs to educate people and promote family-planning programs. The efforts to institute programs with the goal of lowering the growth rate, in both developed and developing nations, have been successful. For example, Iran has successfully lowered growth based on a campaign for contraception. Many nations, including Thailand, Brazil, and Bangladesh, have some form of family planning programs, public awareness, and policies in place to focus on reducing population growth. China's one-child policy, where limitations have been established for the number of children a couple can have, is the only one of its kind, though. Countries sometimes address immigration as opposed to birth rates as a way to reduce population growth.

Impacts of Population

There are two distinct population-related impacts on the environment. The populations of developing countries have one impact, while the populations of industrialized countries have a different impact. In developing countries, populations are continually occupied with acquiring and sustaining basic needs (food, water, and shelter). In comparison, industrialized countries have the basic needs and are more concerned about their desires (cellphones, cars) than basic needs.

Poverty

In countries in which a large percentage of the population lives in severe economic hardship, people are generally more concerned about food, water, and shelter than they are about environmental impact. Many of these impoverished countries have large populations that rely on biomass (wood fuel) for their energy needs. Denuding the landscape depletes the habitat needed for native plants and animal species to flourish and erodes the soil. As farming becomes less productive, it necessitates hunting for game, with the possibility that some species of animals may be hunted to extinction.

Economics

Populations, economics, and the environment are interrelated. A wealthy population requires a wealthy economy and, in an industrialized society, is supported by natural resources. Conversely, an abundance of natural resources will infuse wealth into an economy and has the possibility of creating wealth for the population. As a wealthy population's natural resources are depleted, it has the economic wealth to expand and/or locate new resources. This often occurs at the expense of poor populations and their natural resources. Wealthier nations (the United States, many European countries, and Japan) generally have strong economies that provide medical, educational, and social services for most members of their societies. Poorer nations provide uneven services for their populations. Education in the poor nations may be limited, restricted to males, or based on ethnicity. The wealthy in poor nations can usually obtain medical and educational services.

Culture

Culture is the patterns of human knowledge, belief, and behaviors that are considered the norm for a society. This is based on shared attitudes, values, goals, and practices that characterize the society and can be based on a set of religious beliefs, a common history, or a common goal. The way in which a society treats the environment is impacted by cultural values. These human actions can pertain to agricultural use of the land, fishing practices, land development, resource extraction, or by-products from use including pollution. Cultural influence combined with personal experiences affects how an individual views and treats the environment.

Disease

Disease affects population growth. Death rates, especially infant mortality rates, are lower in industrialized societies than in developing nations. Industrialized societies have better access to medicines, hospitals or clinics, and doctors. Developing countries may have difficulty providing inoculations against diseases commonly considered eliminated in developed countries, such as polio, measles, and tuberculosis. Education, medicines, and preventive measures for HIV infections, available in developed nations, are seriously lacking in the developing countries. Africa has severe issues with HIV and AIDS infections. Malaria, which is almost nonexistent in the industrialized nations, is common in African countries.

Resource Use

By far, industrialized societies use more resources and a larger variety of resources than developing societies. The developing society is primarily concerned about the basic needs of obtaining or providing food, water, and shelter. Food tends to be locally grown, found, or even hunted. Water often comes from a local stream, river, or well. It is usually used without purification and is often carried in containers, instead of being piped into homes. Homes are small, often lacking electricity or indoor plumbing, and often in disrepair. Industrial societies have larger homes, appliances, cars, recreational vehicles, and personal articles. They have indoor plumbing and don't get their water from a local stream. Many industrialized countries utilize dams and aqueducts to acquire their purified water supplies and provide hydroelectric power. They use their own resources and then buy additional resources from other countries. Japan has virtually no resources and must import all its resources. As the population uses more and more finite resources without recycling or discovering new resources, fewer resources are left for the flora and fauna of Earth.

Habitat Destruction

Large populations have a direct impact on the land necessary to support the human population. More land is necessary to grow food, provide space for living requirements, dispose of waste, and harvest and extract resources. These actions all have an impact on the environment and, therefore, on the habitats of other organisms. Loss of habitats for species will continue to grow as the human population continues to grow, further imposing on these habitats.

Populations in both industrialized and developing nations have environmental impacts, although the differences in land use affect habitats differently. Also, industrialized countries tend to have smaller populations but have a larger amount of land destruction than developing countries. Populations in industrialized countries not only use local, regional, or national resources when available, but also use resources from other countries, often from developing countries. The developing countries need the money from their own resources to help them develop. Per capita, the industrialized countries have higher energy usage, greater land use (for their homes, businesses, schools, and recreational activities), and consume more calories (thus, they have a larger land and energy requirement for food production). Due to an industrialized nation's high consumption of food and great use of energy and resources, accompanied by the production of waste, their environmental footprints become quite large. The footprint can reach beyond the industrialized nation and quite often leaves a greater footprint in the developing countries than their own country.

Practice

Human Population Growth		
Human Population (in billions)	Year	Years Elapsed
1	1804	
2	1927	123
3	1960	33
4	1974	14
5	1987	13
6	1999	12

1. Which of the following is NOT a reason that helps explain the change in population?
   - A. Surplus in the availability of food for human consumption
   - B. Availability of food year-round
   - C. The ability to transport food over great distances
   - D. Higher infant mortality in developed countries
   - E. Improvements in medical practices

2. During the past 100 years, human population growth is primarily due to a/an __________ in the __________.
   - A. decrease; death rate
   - B. increase; death rate
   - C. decrease; birth rate
   - D. increase; infant mortality rate
   - E. increase; birth rate

3. If a nation has a growth rate of 2 percent, how many years will it take for the population to double in size?
   - A. 2
   - B. 10
   - C. 20
   - D. 35
   - E. 350

4. A nation currently has a population of 100 million and an annual growth rate of 3.5 percent. If the growth rate remains constant, what will be the population of the nation in 40 years?
   - A. 150 million
   - B. 200 million
   - C. 300 million
   - D. 400 million
   - E. 500 million

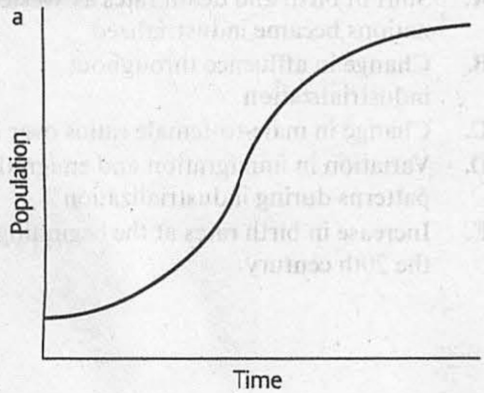
5. On which continent are most of the developed countries located?
   - A. Africa
   - B. Asia
   - C. Europe
   - D. North America
   - E. South America

6. Which of the following issues does NOT directly affect human population size?
   - A. Poverty
   - B. Culture
   - C. Disease
   - D. Habitat destruction
   - E. Government policy

7. Which are the four main factors that affect population size?
   - A. Birth rate, death rate, poverty, culture
   - B. Birth rate, death rate, immigration, emigration
   - C. Poverty, culture, immigration, emigration
   - D. Poverty, female empowerment, ethnicity, disease
   - E. Birth rate, death rate, disease, culture

8. Territorial animals display which type of distribution?
   - A. Clumped
   - B. Random
   - C. K-selected
   - D. Uniform
   - E. R-selected

9. The following logistic growth curve best describes a population as:



A. Increasing quickly and then leveling off
B. Fluctuating above and below carrying capacity for an indefinite amount of time
C. Rising quickly and then decreasing abruptly
D. Growing indefinitely without reaching carrying capacity
E. Fluctuating for a period of time and stabilizing

10. Of the following limiting factors of a population, which is NOT a density-dependent factor?

A. Temperature fluctuations
B. Disease
C. Soil nutrients
D. Availability of mates
E. Predation

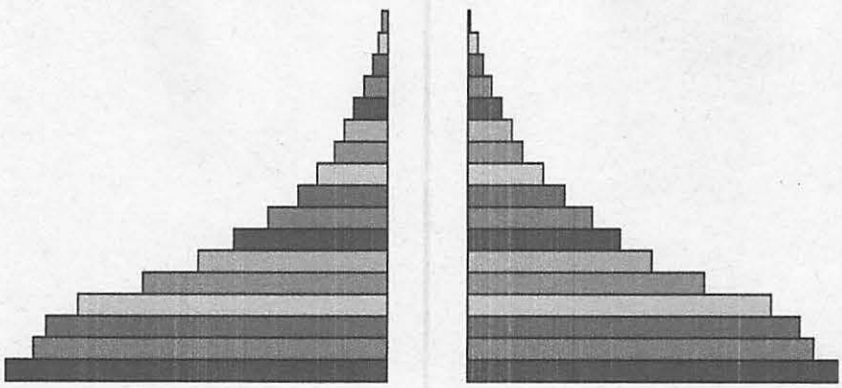
11. Which of the following describes an R-selected species?

A. Very few offspring are produced at once.
B. The gestation period is long and parents dedicate large amounts of energy to nurturing their young.
C. Thousands of offspring are produced at once.
D. They have low biotic potential.
E. They have long life spans.

12. Which of the following organisms shows a Type III survivorship curve?

A. Lizard
B. Oak tree
C. Elephant
D. Mosquito
E. Panda

13. The following age-structure diagram best shows the age structure in which type of population?



A. A growing population with many young
B. A stable population with no growth
C. A population harshly impacted by disease during early-adult years
D. An aging population with few young
E. A population with few individuals entering the workforce

14. Which three components are used as a way to analyze how the environment is impacted by human use?

    A. Culture, poverty, death rates
    B. Technology, affluence, population
    C. Pollution, chemicals, water use
    D. Pollution, affluence, technology
    E. Time, population, affluence

15. The demographic transition model was created to help explain the:

    A. Shift in birth and death rates as Western nations became industrialized
    B. Change in affluence throughout industrialization
    C. Change in male-to-female ratios over time
    D. Variation in immigration and emigration patterns during industrialization
    E. Increase in birth rates at the beginning of the 20th century

Answers

1. **D** The other four answers played a role in the increase seen in the population after 1804. Infant mortality is lower in developed countries. A high infant mortality rate may result in lower population growth.
2. **A** Death rates declined at a fast rate and were the primary reason for the population increase. Birth rates declined later and at a slower rate than death rates.
3. **D** The Rule of 70 is used to determine the doubling time. The formula is $dt = \frac{70}{r}$, where dt = doubling time and r = growth rate. So, $dt = \frac{70}{2} = 35$ years.
4. **D** Again, use the Rule of 70 to determine the number of years and then find the answer: $dt = \frac{70}{r} = \frac{70}{3.5} = 20$ years.

   The question asks "What will the population be in 40 years?" If the doubling time is 20 years, that means there are two doubling times. The starting population is 100 million. At the end of 20 years, the population will be 200 million; this is the first doubling time. The population at the end of 40 years (the second doubling time) will be 400 million.
5. **C** The list in this chapter identifies Europe as having the most developed countries.
6. **D** Although habitat destruction is an effect of population size, it does not directly affect the size of the human population. Over time, destroyed habitat may not be able to support a certain population size.
7. **B** The size of a population depends on its birth and death rates combined with immigration and emigration. Basically, it is the number entering into a population and the number leaving a population at the same point in time.
8. **D** When organisms' territories are spaced evenly from one another, it is considered to be uniform distribution. Organisms that are territorial (such as wolves, lions, and other large predators) require large amounts of space for their territory. Generally, they're evenly distributed.
9. **A** This curve shows a rapid increase, then a leveling off of the population as it reaches carrying capacity. This is the theoretical model, as populations in nature may not act this way.
10. **A** Temperature fluctuations are a density-independent factor because this limiting factor doesn't depend on the density of a population. Temperature changes can affect a species regardless of whether they're densely populated.
11. **C** Because R-selected species put their energy into producing many young that are not nurtured after they're born, they produce thousands of offspring at one time. These organisms are also small, with short gestation periods.
12. **D** Mosquitoes and other insects frequently produce many offspring, and they have a short life span.
13. **A** The large bulge on the bottom indicates a large number of young in this population, with a decline in numbers as the population gets older.
14. **B** The IPAT model was created by Paul Ehrlich and John Holdren in 1974 to examine how technology, affluence, and population work together to impact the environment. Sometimes sensitivity (S) is also incorporated to take into account the sensitivity of an environment when being used by humans.
15. **A** During industrialization, there have been shifts in birth rates and death rates that were hard to explain. In the 1940s and 1950s, Frank Notestein developed a demographic transition model to better explain this phenomenon. The model moves from a pre-industrial stage to a transitional stage to an industrial stage and ends in a post-industrial stage.