**OBJECTIVE:**
- Understand the difference between exponential and logistic growth in naturally occurring populations.
- To study factors which influence human population growth.
- To learn basic terminology used with diseases.
- To study the effects of diseases in regulating population size, particularly regarding sexually transmitted diseases.

**INTRODUCTION**

Populations grow rapidly when provided with ideal conditions (unlimited resources such as: energy, food, water, habitat, etc.). This type of growth is exhibited when there are no limiting factors (biotic potential) and is referred to as **exponential growth**. When plotted, exponential growth has the characteristic **J-shape** (Figure 1). However, natural populations are not allowed to increase exponentially because they are not left unchecked. The environment provides resistance against exponential growth in the form of limited resources, predation and diseases. These factors help to reduce the actual numbers in a population. Because of which, the environment sets the limit for the number of individuals it can support so that there is no net increase or decrease over long periods of time. This limit is what ecologists call the **carrying capacity** (K) for a particular environment. Populations tend to stabilize when they reach the carrying capacity, which is referred to as **logistic growth**. When plotted, logistic growth has a **sigmoid (S) shape** (Figure 1) due to the stabilization of the population as it reaches the carrying capacity.

![Figure 1: Comparison of exponential and logistic growth.](image-url)

Natural populations are maintained around the carrying capacity. If a population rose above the carrying capacity, this population would ultimately crash. For example, whitetail deer living in the woods in Georgia have a population density of 200 deer per 150 acres. During the late 1800's and early 1900's, people began to hunt and exterminate the predator population (bobcats, wolves, coyotes,
mountain lions, etc.) This allowed the whitetail deer population to increase due to a decline of predators. Because the carrying capacity for the whitetail deer population had been exceeded, the population crashed due to starvation. Thus the predators played an important role in keeping the deer population in check and helped maintain a "balance of nature."

In a stable population, there is no net increase or decrease in the number of individuals, which is referred to as zero population growth (ZPG). In any species, however, there are four factors, which determine the actual size of the population. They are:

- **natality** - birth rate
- **mortality** - death rate
- **immigration** - individuals which move into an area
- **emigration** - individuals which move out of an area

For centuries, the human population has been growing exponentially. Environmental resistance factors now have little influence over the human population. Before the 1650, the human population increased relatively slowly. After 1650, the human population began to double.

**Human population:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1650</td>
<td>500 million</td>
</tr>
<tr>
<td>1850</td>
<td>1 billion</td>
</tr>
<tr>
<td>1930</td>
<td>2 billion</td>
</tr>
<tr>
<td>1974</td>
<td>4 billion</td>
</tr>
<tr>
<td>1999</td>
<td>6 billion</td>
</tr>
<tr>
<td>2017</td>
<td>8 billion??</td>
</tr>
</tbody>
</table>

One particular factor, which serves to curb the exponential growth of mankind, is pestilence (disease). Large, high-density populations found in urban areas, often provide ideal conditions for the spread of disease. Epidemics of the plague and influenza have decimated the human population throughout history. Today, one of our biggest fears is AIDS (Acquired Immune Deficiency Syndrome). AIDS is caused by the human immunodeficiency virus (HIV). Although we have a plethora of medical treatments, many disease still remain deadly and virtually untreatable, especially viruses.

There are four basic categories of diseases (not all are capable of becoming epidemic):

**Genetic** - individuals have a defective gene(s) or an abnormal number of chromosomes
- These diseases are not contagious, most are minimally or non-treatable at this time.
- Examples: Down syndrome, hemophilia, Tay Sachs, cystic fibrosis

**Deficiency** - when the individual is lacking (missing) something in their diet, such as proteins or vitamins. These are not contagious and are treatable with dietary supplements. However, the effects of some of these may be permanent.
- Examples: rickets, scurry, beriberi

**Degenerative** - these are the diseases that result due to aging. These could be due to a combination of things such as diet, lifestyle, lack of exercise, aging or some unknown cause. These are not contagious with some having a genetic component to them. Treatment varies with the type of disease.
- Examples: osteoarthritis, atherosclerosis, Alzheimer disease
Communicable - these are caused by an infectious agent (pathogen). These are contagious and the treatment due to the type of pathogen involved. Some are completely treatable, whereas some are not treatable at all.

Examples: chicken pox, influenza, strep throat, and many sexually transmitted diseases (STDs) such as: Herpes, HIV, genital warts, yeast infections, chlamydia, gonorrhea

For today's lab, we will look at the effects of communicable diseases, specifically HIV and AIDS. Communicable diseases are capable of infecting and possibly killing large numbers of people.

Terminology for communicable diseases:

**Pathogen**: the infectious agent. This is what you actually catch. They can be: virus, bacteria, protozoa, yeast, insects, or worms.

**Transmission**: when you transfer the pathogen to another. This can occur through many different methods: touch, food, water, insect bites, contaminated objects, airborne droplets.

**Incubation period**: time period between catching the pathogen and the appearance of the disease. During this time, the pathogen is increasing their numbers. You can be contagious during the later part of this period, even though you may not have any symptoms yet.

**Communicable period**: this is when you are contagious and you can transmit the pathogen to another person. You can transmit before symptoms begin and even after symptoms disappeared.

**Symptomless carriers**: individuals, which have a particular pathogen and can transmit the pathogen. However, they look "healthy" and do not show any signs of the disease. Not all individuals with HIV show the symptoms of the disease.

Although our body has many lines of defense to protect us from invading pathogens, most STDs do not elicit any of our immunological responses. So when they invade our bodies, they can cause havoc. There are vaccines against many diseases, but there are not vaccines for STDs. In many cases, drugs are used to fight most pathogens. Viruses are the exception, since antiviral drugs are very limited. Many of the viral diseases are deadly, and very difficult or impossible to treat. STDs can be viral, bacterial, protozoan or yeast.

Unfortunately, STDs are epidemic on this planet. Some can make life miserable, others can cause sterility, and some can kill you. Every year in the US, there are millions of new cases in addition to the millions of existing (untreated or untreatable) old cases. These diseases are a part of our everyday life. They can contribute to epidemics. Pathogens can mutate, thus making them difficult to treat and eradicate. Due to increased worldwide travel, pathogens can spread quickly (hours or days). Changes in attitude towards sex during the 1970's brought about the sexual revolution and casual sexual relationships. All of this was possible due to the introduction of the birth control pill during the 60's and the decrease usage of condoms. Probably the most important risk factor is multiple sex partners.

**1982 - ACQUIRED IMMUNODEFICIENCY SYNDROME (AIDS):**

Acquired - you get it
Immune deficiency - deficit in the immune system
Syndrome - a myriad of symptoms due to one cause

AIDS is a severe immune system disorder caused by infection with the human immunodeficiency virus (HIV). This virus is composed of two identical strands of RNA. HIV is classified in a group of RNA
viruses know as **retrovirus**, which have the most complicated reproductive cycles. Retroviruses are complicated in that the flow of information is backwards. These viruses have the enzyme, **reverse transcriptase**, which allows retroviruses to produce viral DNA in order to produce more RNA viruses.

One of the characteristics of individuals that are infected with HIV is the reduction of **T cells** and appearance of secondary infections. There are four different types of T cells and each has a specific role in our immune system. When helper T cells (T<sub>H</sub>) are infected, our immune system becomes devastated because T<sub>H</sub> plays a central role in both humoral and cell-mediated responses. T<sub>H</sub> can also affect the activation of macrophages and B cells. HIV looks for a specific glycoprotein receptor on our cells, the **CD4 receptor**. Once the virus has located this receptor, HIV binds, enters, replicates to produce more viruses, which can then circulate and infect other cells. Infected cells may be killed quickly by the virus, by immune response or may live for an extended period of time.

HIV may also lay dormant in a cell's genome for many years before becoming active. When dormant they are called provirus, which are not detectable by the immune system. Then, when the virus replicates, it undergoes rapid mutational changes and overwhelms the immune system. Most people that are infected with HIV do not die of AIDS, but rather from secondary infections such as Pneumocystis pneumonia or Karposi’s sarcoma

AIDS is actually the late stage of HIV infection and is defined by a reduced T cell population and the appearance of 2˚ infections. It takes about 10 years to reach this stage of infection. However, progression is more rapid in infants infected *in utero*, while in the womb. When a person is exposed to HIV and has circulating antibodies, they are considered to be HIV positive.

AIDS is currently considered an incurable disease and the mortality rate approaches 100%. There are numerous antiviral drugs (AZT, ddc, & ddI) used to extend the lives of infected individuals. These drugs do not eliminate the virus but inhibit the viral enzyme, reverse transcriptase. There currently is a new class of drugs called proteases inhibitors which prevents the virus from producing their protein coats. There are other drugs that are used to treat the vast number of opportunistic diseases associated with AIDS.

HIV is only transmitted through the transfer of body fluids such as: blood, semen, which contains infected cells. HIV is not transmitted by casual contact! Mothers can transmit HIV to their fetus during fetal development or nursing. With the advent of HIV screening, this has virtually eliminated blood transfusions as a route of transmission in developed countries.

There are nearly 20 million people worldwide with HIV and 1 - 1.5 million people alone in the US. In 1997, nearly 6 million people worldwide acquired HIV and over 2 million perished from AIDS, including 460,000 children. The number of AIDS cases is expected to increase by nearly 20% per year! The best approach to slow the spread of AIDS is to educate people to practice "safer" sex and to stop the use of non-sterile needles.
STD TRANSMISSION ACTIVITY:
This is an activity to demonstrate what can happen when you have unprotected sex with multiple sexual partners.

Materials:
Test tube with clear liquid, eyedropper

Procedure:

1. The instructor will pass out a test tube with dropper to each person.
2. You are at a singles resort where you are on the prowl to satisfy your insatiable sexual urge. During this night, you will have at least 3-4 sexual encounters with different partners (or however your instructor determines the number of sexual encounters).
3. Before you have your sexual encounter, be sure to introduce yourself and try to remember the sequence of individuals with whom you have "simulated sex."
4. The liquid in the test tube represents body fluids, which you will exchange with a dropper. You should try to exchange the same amount as your partner, so the volume of their body fluids remains relatively constant in your test tube.
5. When instructed to, walk around, mingle and exchange body fluids with at least 3 different partners (or a number determined by your instructor). Be sure you move around (mingle, you're at a singles resort), do not just exchange with individuals around where your seat.
6. Before you leave the singles resort or when you get back from the singles resort, you decide to get an HIV test. The instructor will place a few drops of "Solution X" into your test tube and help you interpret the results.
7. Calculate what percentage of the group is now "HIV positive."
8. Your instructor will help you analyze the transmission process, as the "disease" spread through the class. The explosive rate of infection, as it travels through the class is quite impressive.
9. Remember, this is only a simulation of STD transmission and test results. Your lifestyle choices can make a big difference regarding what happens in real life.

NOTE: It is important to realize that anyone who is sexually active can contract a STD. Your education, ethnicity, socio-economic status, etc., will not protect you. The only way to protect yourself is to abstain from sexual contact or IV drug use. If you choose to be sexually active, learn to practice safer sex. With every sexual encounter, you are being exposed to pathogens from every person that individual has been with. Sexual relations with multiple partners are risky, as is being monogamous with someone who is not, or having sex with an IV drug user. Remember, you can not always tell if someone is infected just by looking at them. The school's Health Center can help answer your questions regarding STDs. They can provide testing or referrals. They even have condoms available.
1. Look at your world population graph; how would you describe its shape?

2. What are some reasons it took so much time for the world population to reach billion, but it took only 12 years to increase from 4 - 5 billion?

3. What are some specific examples, which contributed to the increase in the world population?

4. List a few specific examples, which acted to decrease the ever-expanding population before 1650?

5. What would be some problems with removing top carnivores from the food chain?

6. List some measures that our government could take to reduce population growth in the United States.

7. How many students are in your class today? __________

8. How many had positive test results? __________

   Calculate the % infection rate = # positive / total # students in class. (Show work)

**These questions relate to the STD activity:**
Answer these questions as if you were actually awaiting test results.

9. How did you feel while waiting to get your test results?

10. Were you positive or negative?
11. If you were positive (do not answer if you were negative):
   a) Use 3 adjective to describe how you felt when you got your test results.

   b) How did you feel when other who participated in same behaviors remained disease free?

If you were negative (do not answer if you were positive):
   c) Use 3 adjective to describe how you felt when you got your test results and realized that you "escaped" infection.

   d) How did you feel when other who participated in same behaviors became infected?

Everyone needs to answer the following questions:
12. When engaging in this activity, could you tell an "infected" tube (or individual) just by looking? In disease terminology, what would those individuals be called?

13. What impact might this activity on your future behaviors?

14. What is the name of the virus that causes AIDS?

15. What type of virus is the AIDS virus?

16. What type of cell is usually infected by the AIDS virus?

17. How is the AIDS virus transmitted?

18. Is AIDS currently curable?