

Some Similarities between the Spread of an Infectious Disease and Population Growth

by Jennifer Doherty and Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2007¹

How Does an Infectious Disease Spread?

An infectious disease is any disease caused by germs that can be spread from one person to another. Germs include viruses, bacteria and protozoa. What are some infectious diseases?

What are some diseases that are not infectious?

This activity will simulate the spread of an infectious disease. A simulation is a simplified demonstration of a real biological process. Our simulation will show how an infectious disease can spread from one infected person to other people, who in turn infect others.

Instructions

1. Your teacher will give everyone a cup filled with a clear solution. This solution represents your body. Only one person in the class will have a cup that has been "infected".

Obviously, you should **not drink** from the cup. (In laboratory activities you should never drink or eat anything unless your teacher tells you that it is safe to do so.)

2. In this part of the activity, you will interact with two other students.

To interact with another student, pour all of your solution into your partner's cup. Then have your partner pour all of the mixed solution back into your empty cup. Finally, pour half of the mixed solution back into your partner's empty cup.

Wait for the signal from your teacher, and then move to another part of the classroom and interact with a second student. After you have finished your second interaction, return to your seat.

Estimate how many people you think will be infected. _____

3. Your teacher will come around and put an "infection indicator" in your cup. If you have exchanged solutions with the original infected person or someone else after they became infected, you are now infected and your solution will turn pink. If you have not exchanged solutions with anyone who was infected, your solution will not turn color.

Next, your teacher will ask everyone who is infected to raise their hand.
How many people were infected? _____

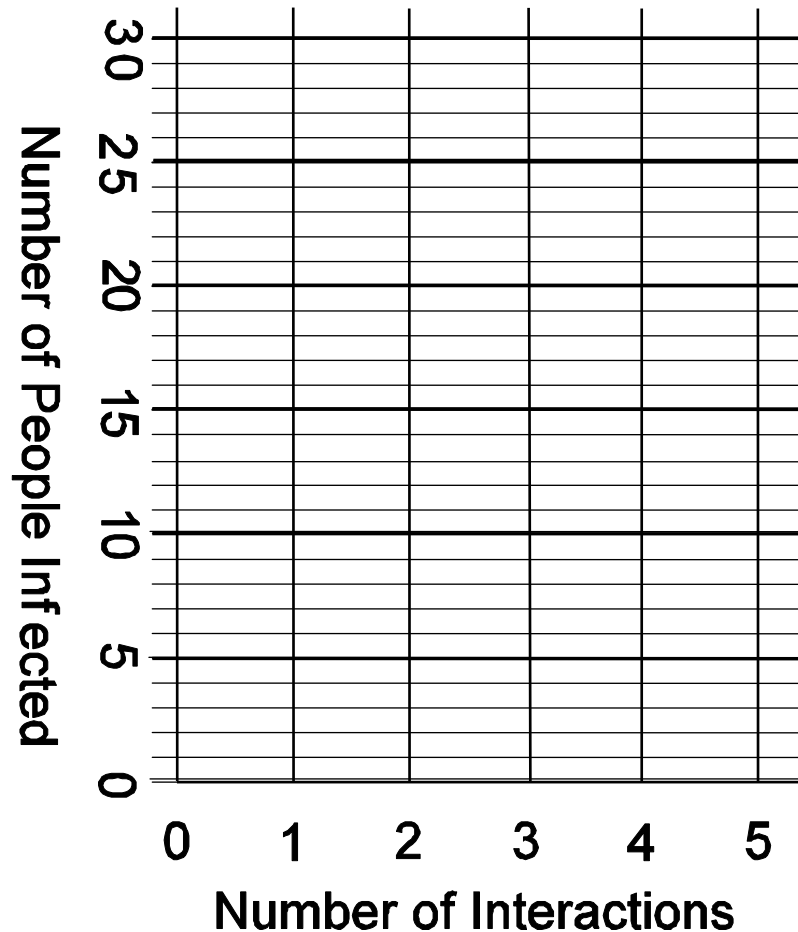
4. You will do another set of interactions, again beginning with only one student with an infected cup. This time there will be three rounds of interactions. For each interaction, be sure to move to a different part of the room with different students.

¹ Teachers are encouraged to copy this student handout for classroom use. A Word file, which can be used to prepare a modified version if desired, and Teacher Preparation Notes are available at http://serendip.brynmawr.edu/sci_edu/waldron/.

Estimate how many people you think will be infected after each student has interacted with three other students. _____

After the teacher has come around with the indicator, write down how many people were actually infected. _____

5. Now you will graph how an infection spreads with increasing numbers of interactions.



First, plot a point to indicate that one person was infected before any interactions.

How many people would be infected after just one interaction? _____

Add this point to your graph.

Next, plot the number of people who were infected after two interactions (from 3 on page 1) and the number of people who were infected after three interactions (from 4 on pages 1-2).

Discussion

6. Did the number of people infected increase by the same amount for interaction 1, interaction 2, and interaction 3?
Which interaction resulted in the smallest increase in the number of infected people?
Which interaction resulted in the largest increase in the number of infected people?

In each interaction, each infected person can infect one new person. Therefore an interaction that begins with more infected people will generally result in more new infections.

7. How many people do you think would be infected if you had four interactions? _____
8. How many people do you think would be infected if you had ten interactions? _____
After the tenth interaction, would the rate of increase in the number of infected people become faster or slower? Explain why.
9. What are some ways that infectious diseases are transmitted from one person to another?
10. What are some ways you can prevent the spread of an infectious disease?
11. Our simulation showed the way a disease could spread if the spread of disease depends on person-to-person contact. Examples of this kind of disease include pink eye, chickenpox and herpes (lip sores). Other diseases, such as colds and tuberculosis, can be spread by germs in the air. How might the spread of these diseases differ from the spread of diseases that depend on person-to-person contact?
12. The spread of the disease in our simulation was very rapid. Multiple people were infected within a few minutes. In real life, infections do not spread as rapidly as in this simulation. Why is the spread of infections slower in real life?
13. In addition to exposure to germs or pathogens, what other factors influence your risk of getting an infectious disease? What defenses does your body have that can prevent you from getting sick, even when you have been exposed to a pathogen?
14. Once you have caught a cold or flu, you do not stay sick forever. How does your body eventually get rid of the viruses that cause a cold or flu?
15. A person who becomes infected with the HIV virus is not able to get rid of the HIV virus. With highly effective modern medical treatment, a person may survive a long time with an HIV infection, but an untreated HIV-infected individual is very likely to develop AIDS and die. Why is a person with an HIV infection unable to get rid of this infection the way a person can get rid of an infection with a cold or flu virus?

Population Growth

There are some interesting similarities between the spread of infectious diseases and population growth, e.g., the increase in the number of bacteria, plants or animals in a population. For example, in a growing population of bacteria, each bacterium can give rise to two new bacteria after about 30 minutes. This results in a doubling of the number of bacteria every 30 minutes, which is similar to the doubling in the number of infected people after the first and second rounds of interactions in the spread of infectious disease activity.

Suppose a single bacterium is placed on an agar plate and the number of bacteria in the population doubles every 30 minutes. How long do you think it would take before there would be 1000 bacteria?

To calculate how long it would actually take for the single bacterium to multiply to form a colony of 1000 bacteria, fill in the number of bacteria at each time in the table.

1	bacterium at the beginning
	bacteria after 30 minutes
	bacteria after 1 hour
	bacteria after 1 hour and 30 minutes
	bacteria after 2 hours
	bacteria after 2 hours and 30 minutes
	bacteria after 3 hours
	bacteria after 3 hours and 30 minutes
	bacteria after 4 hours
	bacteria after 4 hours and 30 minutes
	bacteria after 5 hours

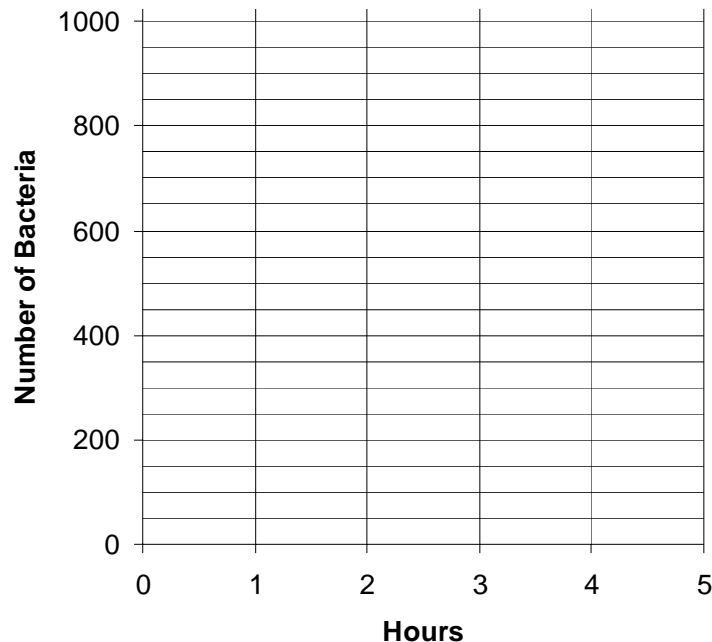
How long would it take for the population of bacteria to increase from 1 bacterium to 500 bacteria?

How long would it take for the population of bacteria to increase from 500 bacteria to 1000 bacteria?

Notice that, when a population doubles every 30 minutes, the number of bacteria in the population increases faster and faster as the population gets larger.

This kind of population growth is called **exponential growth**.

To see what exponential growth looks like in a graph, use the data from the above table to plot the number of bacteria at each time in the graph.



If exponential growth continued for 10 hours, the original single bacterium would increase to a population of over one million bacteria. This illustrates how exponential growth can result in very rapid increase of population size.

In the real world, no population of bacteria or any other biological organism can keep increasing exponentially forever. Why not?

All organisms require resources such as water and nutrients to grow and reproduce. The environment where a population is growing has only a limited amount of resources. As the population gets larger, there will not be enough resources to support continued rapid growth of the population. The rate of growth of the population will slow down, and finally the population will reach a maximum size which is called the **carrying capacity** of the environment. This type of **logistic growth** curve is illustrated in the following figure. The first part of a logistic growth curve looks like an exponential growth curve, but a logistic growth curve levels off as the population size approaches the _____ of the environment.

