Teacher Preparation Notes for Some Similarities between the Spread of an Infectious Disease and Population Growth

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Spread of an Infectious Disease

Equipment and Supplies:

Small Dixie cups (3-5 oz; 2 cups per student)
Chemical (such as Calgon water softener or NaOH) to mix with water to produce a clear solution with a basic pH of 10 or above
Phenolphthalein pH indicator*
(you can substitute any basic indicator that is clear until in a basic solution)
Small container with eye dropper or pipet for phenolphthalein
Container for mixing basic solution

*__Purchase from Carolina Biological:__
Phenolphthalein Indicator Solution 87-9965 $6.65 500 mL

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Teacher Instructions:

1. Prepare a basic solution to be used as the infected solution. Make sure the solution will still change color when your indicator is added when diluted to 1/8 strength.

2. Prepare two sets of cups (each with one cup per student) for the two sets of interactions (items 2 and 4 on page 1 of the student protocol). For each set, fill one of the cups one quarter full with the infected solution. Fill all the other cups one quarter full with plain water.

3. Explain that each student will receive a cup containing a clear solution. Tell the students that the solutions represent bodily fluids. Explain that after they receive their solutions each of them should first interact with one other student. The interaction is accomplished by one student pouring all of their solution into the partner's cup. Then that partner pours all of the solution back into the empty cup. Then the two partners each take half of the solution in their cups and move to a different part of the room for their next interaction. After the first interactions have been completed, give them the signal for their second interaction.

4. After students have completed two rounds of exchanging solutions, have them go back to their seats and predict the number of infected people. Go around the classroom and drop the phenolphthalein indicator in the cups; as you're doing so, tell the students that you are putting an infection indicator into their cups. If they have exchanged solutions with the original infected person in the class or someone who came into contact with the infected person, they are now infected and their solution will turn pink. If they have not exchanged solutions with anyone who was infected, their solution will not turn color. Have a show of hands to determine the number of people who were infected.

[1] These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron.

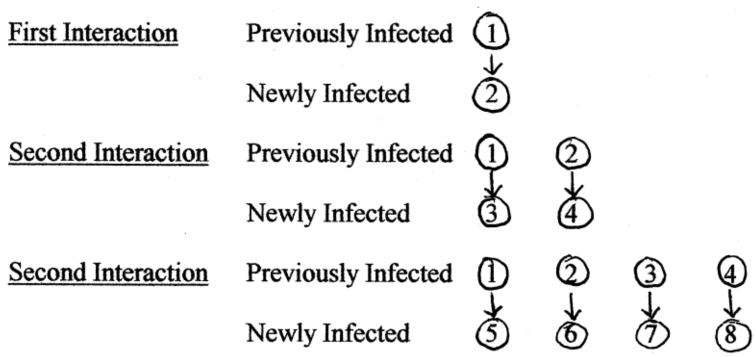
5. Now repeat the process, but have three interactions instead of just two.

6. If you have enough time and your class size is large enough, it may be helpful to have another round with four interactions (you will need another set of Dixie cups and your infected solution will need to react with the indicator when solution is at 1/16 strength).

7. Dispose of the liquid by rinsing it down the sink with plenty of water.

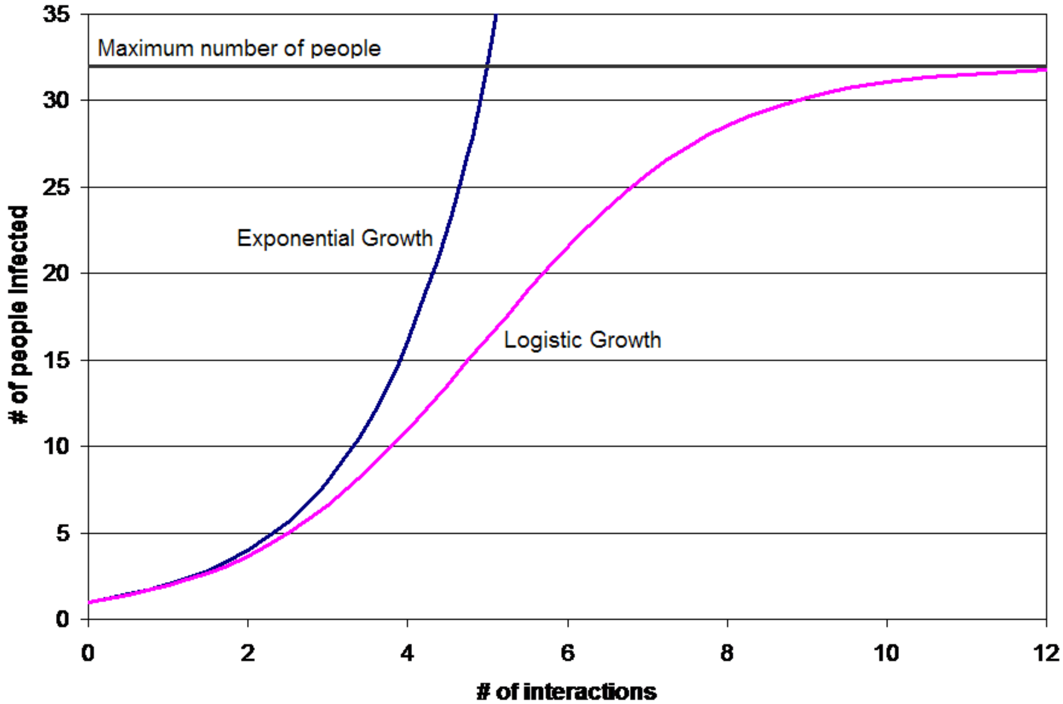
Background Information for Infectious Disease Discussion Questions in Student Protocol:

6-7. In order to predict the subsequent spread of the disease, students should notice the approximate doubling of the number of infected people after each round of interactions. The following graphic may help your students to understand this process.



This doubling in each generation results in <u>exponential growth</u> (see the figure on the next page). This is similar to exponential growth of a population with abundant resources, as discussed in the second half of this activity.

8. As the number of infected students gets larger, it is increasingly likely that one infected student will interact with another infected student, which will slow the rate of increase in the number of infected individuals. This results in a logistic growth curve, with the maximum number of infected students equal to the total number of students in the class (see the figure below). This resembles population growth, which may be rapid when resources are abundant, but then slows as population size approaches the carrying capacity of the environment.



9. Ways that diseases are transmitted from one person to another:
-- droplets in the air (e.g. cold, flu, tuberculosis)
-- via food or water (e.g. Salmonella, food poisoning)
-- via mosquitoes, ticks (e.g. malaria, West Nile virus, Lyme disease)
-- physical contact (e.g. pinkeye, herpes, chickenpox, sexually transmitted diseases)
You can catch an infectious disease due to a virus by getting it on your hands and then touching your mouth or eyes or eating food you have touched with unwashed hands. The AIDS virus is **NOT** spread this way.
Ways that HIV/AIDS is transmitted from one person to another:
-- by having vaginal or anal intercourse with a person who is infected with HIV
-- by sharing needles with someone who is infected with HIV
-- from an infected mother to her baby during pregnancy, birth or nursing

10. Ways to prevent infection:
-- Avoid close contact with people who are infected.
-- Use tissues if you have a cold or flu and throw them away.
-- Wash hands especially before eating, after using toilet, or after contact with someone who has an infection.
-- Don't touch other people's blood or body fluids (e.g. soiled tissues from someone who has a cold).
-- Don't share toothbrushes, eating utensils, etc.
-- Eat nutritious food to keep the body healthy.
Ways to prevent HIV infection:
-- Abstain from sexual contact (or reduce risk by a monogamous mutually faithful relationship and use of condoms).
-- Don't use intravenous drugs.
-- Treatment of a pregnant woman can reduce the risk of infecting her baby.

11. Differences in spread of airborne vs. person-to-person contact diseases
Airborne diseases can be spread to multiple people at the same time and can be spread to people who are nearby but not in direct contact.

12. Why is the spread of infection slower in real life?
The rate of interactions with other people is typically slower. Also, even when you have contact, you don't always transmit any germs or enough germs to start an infection. If a person does get enough germs to start an infection, it takes a while for the germs to reproduce to high enough levels for that person to become contagious.

13. What other factors influence your risk of getting an infectious disease?
Susceptibility to infection can be reduced by good hygiene practices, such as washing your hands after possible exposure to pathogens before touching your eyes, mouth or mucous membranes where infection may occur. Susceptibility may be increased by a weak immune system due to age, medication, previous illness, inadequate nutrition, etc. Resistance to a specific infectious disease can be increased if you have had this infectious disease previously or been vaccinated against this disease (see 13 below).

What defenses does your body have that can prevent you from getting sick, even when you have been exposed to a pathogen?
Important defenses include barriers such as the skin and mucous membranes, chemicals such as acid in the stomach, inflammation and phagocytic cells. The specific immune system also contributes to defenses against infection, but more slowly, as discussed in 13 below. (Any good biology text will provide additional information.)

14. How does your body eventually get rid of the viruses that cause a cold or flu?
If a cold or flu virus gets past the first set of defenses (such as the mucous membranes) and infects your body, your immune system is stimulated to produce specific immune system cells (B cells and T cells) that can effectively fight the particular virus that has infected your body. This response takes time, especially the first time you are exposed to a specific virus, so you are sick with a cold or flu until the specific immune cells become effective enough to rid your body of the virus.

After an infection, your body will have memory cells which can produce a rapid defense if you are exposed to the same virus a second time, so you are able to fight off a second infection rapidly and effectively, so the level of viruses is kept low and you may never even feel sick. A vaccination induces the production of memory cells which can mount a rapid defense against that particular infection, so the flu vaccine helps people to avoid infection with the specific strains of flu included in a particular flu vaccine.

14. 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?
There are many reasons why our bodies are unable to get rid of an HIV infection. One important reason is that HIV infects an important type of T cell, the Helper T cell, which is crucial in mobilizing other immune cells to fight infection. As more and more Helper T cells are killed by HIV infection, the body becomes less and less able to fight infections, including HIV infection. Another reason why the body cannot get rid of HIV infection is that the genetic material of the HIV virus is incorporated in the DNA of infected cells, and some of these infected cells can survive undetected by the immune system over long periods of time.

Population Growth

If the population of bacteria doubles every 30 minutes, there should be 512 bacteria after 4 hours and 30 minutes and 1024 bacteria by 5 hours. The increasingly rapid increase in the number of bacteria is characteristic of exponential growth. Eventually, population growth will level off as population size approaches the carrying capacity of the environment, i.e. when there are not enough resources to support any more individuals in the population. This leveling off is shown in the logistic growth curve. In the real world, population growth often does not follow a logistic growth curve. For example, when environmental resources first become limiting, females may use stored resources to reproduce, so the birth rate may not decline immediately and the population may exceed the carrying capacity for a while. If a population exceeds the carrying capacity and degrades the environment, this could result in lower carrying capacity and a smaller maximum population size. Other environmental changes, such as changes in the weather, can also contribute to fluctuations in population size in natural populations.

The question on the top of the next page provides a dramatic example of the reproductive potential of a mammal and illustrates that other organisms besides bacteria can reproduce exponentially. This question can provide a helpful introduction to a discussion of natural selection.

How many bunnies?

Suppose that you start with 1 adult female and 1 adult male bunny. Assume that each pair of breeding adults produces 20 baby bunnies in the breeding season of one year (half female and half male). Suppose each baby bunny matures to become a breeding adult by the breeding season of the next year. Suppose all the bunnies live out their natural lifespan (7 years) and continue to reproduce throughout their adult lives. How many bunnies do you think there would be after 5 years (just guessing, without calculating)?

Calculate how many bunnies there will be in 5 years.

Year	# Breeding Males	# Breeding Females	# Baby Bunnies	Total # Bunnies
0				
1				
2				
3				
4				
5				

Extrapolating this exponential population growth raises the question: Why isn't the world covered in bunnies?

Teaching Points

- Spread of infectious disease from person to person in a population can result in exponential increase in the number of infected people.
- Similarly, when population size doubles repeatedly, this results in exponential growth.
- Population growth is limited by the availability of resources.
- The maximum population size that an environment can sustain is called the carrying capacity.
- As population size approaches the carrying capacity, the rate of growth in population size decreases, resulting in a logistic growth curve.
- Additional teaching points, if desired, include ways infectious diseases spread, ways to prevent spread of infection, the concept of a germ population growing in an infected person's body, and defenses against infection.