**Activity 5.5.3 Super Bugs and the Spread of Diseases**

Government agencies and pharmaceutical companies have been warning us about it for years, and now their projections have become a reality…THE SUPER BUG IS HERE! ([Time Article](http://time.com/4362693/senators-hatch-and-bennet-stop-superbugs/)) This strain of antibiotic resistant bacteria has elevated the need for research on the spread of diseases so that the impact on the population is as limited as possible. Disease forming bacteria and viruses are dubbed pathogens, many of which lead to minor complications while others spawn life-threatening infections.

To better understand the spread of disease, consider the following scenario:

Your school sponsors a field trip to the New Britain Museum of American Art (NBMAA). Unknown to your chaperones and the administration at the museum, an [indirectly transmitted](http://dhss.delaware.gov/dph/files/directindtranspi.pdf) disease is currently spreading at the museum. You and your classmates are about to walk into an “artistic petri dish” that is spreading this infectious disease. Suppose the spread of the illness in the museum is modeled by the exponential equation  where P(t) is the total number of people infected after t hours.

Throughout this problem, assume that a large number of visitors have made plans to attend the museum’s full day activities.

1. Prior to walking into the museum, estimate the total number of people infected with the disease. Show how you arrived at your answer and round to the nearest whole person.
2. Doctors have determined that this particular pathogen does not present symptoms to those who contracted the disease for a minimum of six hours. How many individuals will unknowingly have the disease before showing signs of having it?
3. Several days after the first case is diagnosed, the State of Connecticut Department of Health wants to determine the maximum number of infected visitors. Determine this number, and explain or show work that supports your claim.
4. Using your understanding of functions, explain how you know that the answer found in #3 is maximum value.
5. The state health officials recommend that a public venue, like the NBMAA, notify its guests of an outbreak, if more than 25 visitors are identified with having the pathogen. Assuming a new test identifies infected individuals instantaneously, how many minutes would pass before they would need to notify the visitors? Show all work and round your answer to the nearest minute.
6. Often, biologists can determine a function that models the percentage of a population that is infected with a disease. A biologist decides that an epidemic spreads through a population of a city according to the model, where p(t) represents that fraction of the city’s population which has come down with the disease, and t is in weeks. How long will it take for 90% of the city to become infected? Round your answer to the nearest day.

Knowledge of bacterial growth has lead researchers to a better understanding of how to halt the growth and at times eradicate it all together. Bacteria self-replicate by dividing once they reach a certain size. The primary means of eradication are an alteration in the conditions where the bacteria are reproducing (i.e. remove the food supply for the bacteria) or by altering the DNA of the bacteria prior to its split, resulting in a lethal mutation. Antibiotics are at the center of bacterial pathogen extermination.

The half-life of a bacteria is the time required for an environmental change or DNA alteration to reduce the bacterial colony to half of its original size. Half-life models come in the form of , where A(t) denotes the colony size at time t and A(0) is the size of the population prior to decay. The difference between an exponentially decaying situation and the growth models seen in prior problems, is that in the decay setting, < 1.

1. Show that if  and if [the half-life amount is one-half of the original amount] then, . Show your work.
2. A known antibiotic solution claims to reduce the half-life of the bacterial colony in the museum to 10 days, and it was measured that there were initially 50,000 microns of bacteria in the museum. If the safe level for this bacteria is 1,000 microns, when will it be safe to let patrons back into the museum? Round your answer to the nearest number of days. (Hint: )
3. A new strain of super bug seems to be extremely resistant to even the strongest antibiotics being used. The following table shows lab readings for using Carbapenems\* (Meropenem and Imipenem), considered the world’s most potent antibiotics, on a newly unnamed super bug.

|  |  |
| --- | --- |
| **Time (weeks)** | **Thousands of Bacteria (in Microns)** |
| 4 | 15.3726 |
| 8 | 12.7645 |
| 12 | 10.5989 |

Clearly, the antibiotic is work, but very slowly. Determine the exponential decay rule that models the decay function, in the form, where c and k are constants. Round your final values to 5 decimal places. Show all work.

1. Using the equation you found in #9, estimate the time, in weeks, when the bacteria drop below 10,000 microns.
2. After 8 months, how many bacteria will be present?
3. If a patient is considered “pathogen free” when less than 500 microns of the bacteria remain, how long will the patient be required to stay on the antibiotic?

\* Carbapenems are the class of antibiotics that have both the highest rate of success as well as the shortest success cycle for bacterial infections.