CONTAGION:
THE SPREAD OF DISEASE

1. Executive Summary

Contagion: The Spread of Disease consists of three simulations (plus optional extensions) designed to help students understand epidemiology and the transmission of disease.

Target Audience	High school grades 9–12, regular through Advanced Placement
Nature of the Material	Three interrelated simulations, which can be incorporated into all or some of the following courses: biology, anatomy and physiology, AP Biology, English, world history, mathematics, and health
Prerequisites	None for Contact Tracing simulation. Basic knowledge of graphing required for Throw of the Dice simulation. More advanced graphing skills required for Which Well? simulation. Some extensions require more advanced mathematics background
Time Required for Full Implementation	Overall unit of study requires a minimum of 3 hours. See section 4, "Content," for requirements by simulation. Some activities containing extensions will increase required time

The unit was developed in the matrix of the 1999 annual Howard Hughes Medical Institute (HHMI) Holiday Lectures on Science, "2000 and Beyond: Confronting the Microbe Menace." A DVD was developed around the four lectures that compose the series, and it includes many different demonstrations and computer graphics that enhance the learning experience. The developers of this unit added ancillary discussions and teacher-directed questions to clarify and involve the students. The DVD is available free of charge to educators from the Howard Hughes Medical Institute (www.hhmi.org). Note that these sequential simulations may stand alone and be used without the DVD.

The simulations allow students to actively participate in different aspects of epidemiology. They investigate historical events and gather data from simulations of epidemics. The goal is for students to advance their problem-solving skills not only for science class but also for all their subjects.

2. Learning Goals

The overall learning goal of the three simulations is to develop a deeper understanding of disease transmission and epidemiology. There are specific objectives and recommendations for evaluating learning in the description of each simulation in section 4, "Content."

3. Requirements

Time Requirements	A minimum of 3 hours overall; extensions may require additional time	See section 4, "Content," for time requirements in each simulation
Facilities Requirements	Activities can be accomplished in anything from a standard classroom to a large lecture hall	The ability to move about the room freely enhances the Contact Tracing simulation
Equipment Requirements	Computer for viewing DVD Equipment for projecting DVD contents onto screen (optional) Overhead transparency projector for simulation I	Other media may be available from HHMI, which may require different equipment (e.g., VCR and monitor)
Books, including textbooks	None	
Other Resources Required	Simulation I: Test tubes, 1 per student; < 0.1 M NaOH; phenolphthalein solution; eye droppers or plastic transfer pipettes; 2 decks of playing cards	Talcum powder/cloudy cornstarch solution with iodine as the indicator is an alternative
	Simulation II: Cups of 3 different colors for each student, 1 die per student	Use multicolored dice if you plan to do the extensions
	Simulation III: 20 photocopy acetates, 2 different colors of wet-erase markers per group, overhead projector	Alternatively, paper photocopies can be distributed to groups

4. Content

Overview

This unit calls for each student to track the course of HIV transmission, follow the spread of flu among friends, and drop into the midst of a cholera epidemic, personalizing the adventure of epidemiological research. Incorporating problem-solving, writing, and math skills, this experience can be used solely in the science class or extended into other cooperating classes, such as health, math, English, and history.

Contact Tracing, a simulated exercise in HIV transmission and tracing, highlights how easy it is to transmit a disease and how difficult it can be to trace its origins. This unit provides a user-friendly version of a well-known activity, various iterations of which appear on the Web, while the next two activities are completely original to the developers.

Throw of the Dice places students in the midst of a flu epidemic as they study various factors that are involved in the spread of disease. The student investigators analyze scenarios that are "happening" in their own classroom.

Which Well? transports students back in time, where they become medical detectives following in the historical footsteps of Dr. Snow as he tried to halt a 19th-century cholera epidemic in London. To crack the mystery, they utilize their problem-solving, graphing, and writing skills. In the course of the inquiry, they also place the study in the historical context of disease and germ theory.

The lesson plan for each simulation includes correlations to the "2000 and Beyond: Confronting the Microbe Menace" DVD, as well as teacher instructions, suggestions for evaluating students, extensions, and Web connections. Students at all levels of achievement can be involved in and learn from these activities. If time permits extensions, activities using higher-level thinking skills may be incorporated into the basic unit structure.

Simulation I

Activity: Contact Tracing

Time Frame: 45+ minutes including discussion time

Materials: test tubes (one per student), <0.1 M NaOH, phenolphthalein solution, eye droppers or plastic transfer pipettes, two decks of playing cards for the alternate mode of controlling simulated fluid transfer

Teacher Directions

- In advance of class, prepare a set of test tubes, one for each student in your class. You may use small disposable paper cups or vials instead. Fill each vessel approximately 1/3 full of clean tap water (basically the tubes and water must not buffer the small amount of base that will end up in the tubes). "Infect" one tube with a dilute solution (<0.1 M) of NaOH. This will be "patient zero's" test tube. The exact concentration isn't as important as safety. (You may also use ammonia, but the smell may give away the secret of which tube is infected.)

- Prepare a dilute solution of phenolphthalein by dissolving a small very amount of the powder in isopropyl alcohol and then diluting with water. The indicator is very sensitive and exact quantities are not important to this activity. You may wish to test the reaction of your base with the indicator to make sure that the reaction occurs as expected. In general, a good rule of thumb is to take one or two drops of the dilute solution (<01. M), which you are using to infect patient zero, and dilute that with an additional 100 ml of water. If the phenolphthalein turns magenta, both your indicator and the patient-zero solution should work properly.

Details

- **Watch Lesson 1/Chapter 17 on DVD**
    - Ask: What are the principal risk factors for becoming infected with HIV?
        - Do not provide answers at this time. Use this as an opportunity to investigate what the students already know, or think they know, by brainstorming. Indicate that you will come back to this question later.
- Ask: Historically, how did this understanding of the transmission of HIV develop?
    - Again do not provide answers at this time.

- **Activity: Simulated HIV Transmission**
    - When you are ready to begin the activity, distribute tubes and plastic transfer pipettes or inexpensive eyedroppers.
    - Outline the procedure with the students before beginning the simulation.
    - If your students are reasonably mature, you can just instruct them to wander around the class and exchange fluids. If you are concerned about the maturity level of your class, see below for a method of controlling the fluid exchange.
    - After about 10 minutes (more if they are shy, less if they are getting out of control), stop the activity and have them line up for "testing."
    - Add a drop of phenolphthalein to each tube, and have those whose tubes turned magenta stand off to the side and allow the rest of the class to sit back down.
    - Ask: For what have we tested?
    - Answer: Base
    - Ask: What do the base and the fluid exchange simulate?
    - Answer: Virus and its transmission by fluid exchange.
    - Then have the class play epidemiologist and, through contact tracing, establish who in the class was patient zero (i.e., the one student whose solution was initially contaminated).
    - On the board have each person who tested positive list all their contacts (fluid exchanges) in chronological order. Based on that information, it should be possible to establish who started the epidemic in your classroom. You may wish to draw a branching flow chart or tree diagram to explicate the "viral" pathway through your class.

- You can highlight each "positive" case with a different color chalk or marker.
- Return to the questions that began the activity, discussing the spread of the AIDS epidemic and how HIV is transmitted and the evolution of the understanding of HIV transmission.
- Discuss news stories about the evolution of drug resistance and the development of drug-treatment strategies to counteract this problem.

Hints

It may be necessary to "cheat" and make sure the tube with the NaOH goes to a student whom you know to be sociable. The activity does not succeed if the contaminated tube goes to a shy student who doesn't readily participate.

If you feel that your students will get too silly, or you have a class that has an unbalanced gender distribution, you may need to use an alternative method to arrange fluid exchange, as described in the paragraphs below.

Before class prepare two decks of cards so that they are in exactly the same order. (Ace to king in suits works well.) As your students enter class, pass out the cards from one of the decks. After everyone is seated, take the second deck and remove all those cards from this deck that are left in the first deck (those cards which you did not distribute). You then have in your hand a partial deck that matches only those cards that you distributed to the class.

When the activity begins, you carefully explain that they are no longer people. No longer male or female. They are cards and the cards will exchange fluids. Then, after shuffling, you can draw pairs from the partial deck in your hand, instructing those who hold these cards to exchange fluids. If and when someone complains about a particular pairing, you can reiterate that they are not exchanging fluids, but it is the seven of diamonds and the two of hearts who are engaging in unprotected sex.

At the conclusion of a period of random mating, the tubes are tested. Through contact tracing you attempt to identify patient zero. This method takes longer than the student-directed fluid exchange because each pair has to be called out one at a time by the teacher.

Similar activities can be found on the Web, some for more elementary levels that use talcum powder/cloudy cornstarch solutions with iodine as the indicator.

Cleanup of phenolphthalein can be a problem. Rinsing the test tubes and all glassware with alcohol will reduce your aggravation.

Evaluation

After the discussion and contact tracing, students will write a dialog between a public health official and a patient. The dialog should contain information detailing the transmission of HIV and explaining the purpose and methods of contact tracing.

Possible Extension

Students can contact the local public heath office for information on disease demographics in their community.

Web Connections

- tc.unl.edu/nerds/preser/sec/98nerds/aids/aids.htm
- www.accessexcellence.org/MTC/96PT/Share/latta.html
- www.aegis.com/topics/timeline/default.asp
- www.thebody.com/cdc/factv.html
- www.avert.org/historyi.htm

Simulation II

Activity: Getting a Disease Is Just a Throw of the Dice

Time Frame: 50+ minutes (may run to 100+ minutes with extensions)

Materials: Cups of three different colors for each student, one die per student (multicolored for the extensions)

Details

- **Watch Lecture 1/Chapters 4 and 5 on DVD**
  - Discuss living conditions and the state of medical science during the 14th century.
  - Discuss methods of sanitation and water purification.
  - Discuss historical standards of personal hygiene.
  - Discuss germ theory and how prior to the 19th century the causes of disease were generally misunderstood.
  - If possible, coordinate with the history teacher.

- **Watch Lecture 1/Chapters 15 and 16 on DVD**
  - Discuss the possible causes of illness in the picnic scenario:
    - Bacterial/viral contamination
    - Poisoning
    - Drug overdose
    - Toxins in the food
  - Ask: Why didn't the family and friends of the sick individuals get sick?
  - Ask: How does this present situation compare with what might have happened at a similar picnic taking place in the 14th century?

- **Watch Lecture 2/Chapters 18 and 19 on DVD**
  - Ask: How do bacteria spread? How did the bacteria spread in the airplane? How do you get the flu?

- **Activity: Getting a Disease Is Just a Throw of the Dice**
    - See the student worksheet in the appendix for a detailed description of play. Distribute worksheet to all students.
        - The handout refers to cups in the colors of red, white, and blue. If you are unable to obtain those colors, either change the instructions on the worksheet prior to duplicating it for your class or be very explicit about the changes in your classroom.
        - Because desk arrangements may vary, you may have to be creative in setting up "infection zones" in an auditorium or a nonstandard classroom.
    - Specifically ask: How does the rate at which infection spreads compare between simulations I-A and I-B?
        - In graphing the results for the simulation report, you should suggest the use of different colors for each condition (i.e., healthy, infected, immune).
        - While you can use any lab/simulation report format you customarily employ, infuse writing into the conclusions and require that they be a minimum of one to two paragraphs per simulation.

- **Watch Lecture 4/Chapter 5**
    - Ask: What could affect the emergence of a new virus?
    - Ask: How does this relate to Ebola and the outbreak scenarios?

- **Watch Lecture 4/Chapters 14–18**
    - Ask: What is the difference between a pandemic and an epidemic?
    - Ask: Why do you need a new flu vaccine every year?

Evaluation

Students will write up lab reports, the contents of which will vary according to the collected data, and present their data to the class. The following questions may be used either to guide the students in preparing their reports or as follow-up discussion questions after the reports are presented:

- How does the change between simulation I-A and I-B change the likelihood of an individual getting the flu?
- When comparing simulations I-B and II, how does the time of contagion affect the epidemic?
- When comparing simulations I-B and III, how does exposure distance affect the epidemic?
- How does proximity in the classroom affect the transmission of airborne diseases?
- What other factors affect the intensity or length of an epidemic?
- Why do epidemics "burn out"?

If time permits, students might also develop, storyboard, and script an episode for the forensic television show of their choice (e.g., *Crossing Jordan*, *CSI*, *CSI: Miami*) based on the investigation of a virulent flu epidemic initiated by a terrorist act.

Possible Extensions

Conduct simulations IV and V.

Web Connections

- www.cdc.gov/default.htm
- www.cdc.gov/ncidod/diseases/flu/fluvirus.htm
- www.nih.gov/
- www.pbs.org/wgbh/amex/influenza/

Simulation III

Activity: Which Well?

Time Frame: 90+ minutes

Materials: 20 photocopy acetates, two different colors of wet-erase markers per group, overhead projector

Teacher Directions

- Prepare a set of 20 different overheads by photocopying from the masters. You have been provided with two sets of masters (see the appendix). One is a reverse set to be used when photocopying onto acetates. The other direct set can be photocopied onto paper. By using a reversed set, you will photocopy the image on the underside and be able to reuse the acetates from class to class.
- Each of the 20 student data sheets has a different set of coordinates for the deaths, but the same coordinates for the wells. Above the word "Well" in the data table is a sequence number (1–20) to allow you to keep track of the data sheets.
- While you can photocopy on plain paper and have the students compare their results, the effect of the fully aligned set of maps on an overhead is quite impressive. You may want to align the sheets ahead of time and punch holes in the border to assist in lining them up on the overhead. (Photocopy machines are temperamental, and your sheets will probably not line up with the edges unless you are exceptionally careful in photocopying the originals).

Details

- Watch Lecture 1/Chapter 8
    - Ask: Where do epidemics come from?
    - Ask: Where do emerging diseases come from?

- **Activity: Which Well?**

  - See the appendix for the student worksheet. Distribute the handout to all students.

  - Give each pair of students an acetate and two different-colored erasable markers. Instruct them to mark and label each well and to put a dot on the map for each death. (The instructions in the student worksheet refer to red and black markers, but any two different wet-erase markers that work with your overheads are fine; just remember to either amend the directions or be very explicit in your oral explanation.)

  - The death data for the sheets will clump around the affected well. Overlapping the sheets emphasizes the strength of the data correlation between deaths and the Broad Street well. Overlap as many sheets as possible on your overhead projector.

  - You do not have to use all 20 sheets to get the effect; any reasonable subset of the data will do.

  - On these data sheets and grids, the Broad Street well plots at 56, 55 and is designated well 7. (A copy of Dr. Snow's actual map is included in the appendix.)

    - After the simulation, lead a discussion on epidemics in societies before the acceptance of the germ theory of disease.
    - Ask: Why didn't everyone die?
    - Ask: Why didn't everyone get sick?

- Watch Lecture 4/Chapters 31and 32
  - Ask: How has global travel changed the dispersal of disease?
  - Ask: How was West Nile virus introduced into the U.S.? What is the vector? What is happening?
  - Ask: What is the source of dengue fever? What is the vector? How was it introduced to the U.S.?
  - Ask: What does the U.S. Customs Service do to try to prevent disease? Besides human diseases, what other diseases affect our society? Discuss animal diseases (like mad cow, foot and mouth, and plant diseases).

Evaluation

Students will create maps and answer the questions on the student worksheet. If time permits, they might also write a newspaper article for a U.S. newspaper, interviewing Dr. Snow in 1854 following his removal of the well handle. The article should explain the cholera epidemic and his theory of disease transmission. Students might also prepare a timeline of the development of the germ theory of disease, highlighting Dr. Snow's contributions.

Possible Extensions

- Discuss E. coli contamination of hamburgers.
  - Ask: Is this an epidemic?
  - Ask: Why wouldn't the cholera epidemic Dr. Snow traced back to one water pump and today's occasional E. coli outbreak be susceptible to contact tracing? Why are these bacterial diseases spread in the same way as toxins or poisons rather than as infections?
    - ß Because of modern sanitation, many foodborne bacterial infections seem to have point sources. There are limited or no secondary infections because person-to-person transmission is reduced or eliminated by common hygiene and sanitation.
  - Ask: What might happen if a point-source epidemic, such as one started by contaminated beef, happened in a third world country?

- Write a TV newscast about an outbreak of pneumonic plague (a bacterial disease spread by fleas which are carried by rats) in India. Students should focus on sources of large populations of rats, such as food warehouses and grain storage facilities. The 1990s outbreaks can be used as examples. Students should provide suggested solutions in their newscast.

Web Connections

- www.ph.ucla.edu/epi/snow.html
- www.cdc.gov/ncidod/eid/index.htm
- www.epidemiology.tulane.edu/broad_street.htm

5. Assessment

As noted in section 4, "Content," each simulation has its own opportunities for students to demonstrate what they have learned.

Simulation I (Contact Tracing)

After the discussion and contact tracing, students write a dialog between a public health official and a patient. The dialog should contain information detailing the transmission of HIV and explaining the purpose and methods of contact tracing.

Simulation II (Throw of the Dice)

Students write up lab reports, the contents of which will vary according to the collected data, and present their data to the class. If time permits, students also develop, storyboard, and script an episode for the forensic television show of their choice (e.g., Crossing Jordan, CSI, CSI: Miami) based on the investigation of a virulent flu epidemic initiated by a terrorist act.

Simulation III (Which Well?)

Students create maps and answer the questions on the student worksheet. If time permits, they also write a newspaper article interviewing Dr. Snow about the cholera epidemic of 1854 and his theory of disease transmission, and/or prepare a timeline of the development of the germ theory of disease, highlighting Dr. Snow's contributions.

6. Alignment of Content and Standards

The following excerpts from the National Science Education Standards (NSES) and the Florida Sunshine State Standards (sunshinestatestandards.net) suggest ways in which the three simulations reinforce student learning goals. (The curriculum developers' emphases are marked in boldface.)

National Science Education Standards

Individuals have some responsibility for their own health. Students should engage in personal care—dental hygiene, cleanliness, and exercise—that will maintain and improve health. **Understandings include how communicable diseases, such as colds, are transmitted and some of the body's defense mechanisms that prevent or overcome illness**. (NSES, p. 140)

Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. **Others are the result of damage by infection by other organisms**. (NSES, p. 157)

The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted. (NSES, p. 197)

Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with **biological hazards (pollen, viruses, bacterial, and parasites)**, with social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking). (NSES, p. 169)

Florida Sunshine State Standards

Science

The student understands that, in the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism and that, in the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings. (SC.H.1.4.6)

The student knows that scientists assume that the universe is a vast system in which basic rules exist that may range from very simple to extremely complex, but that scientists operate on the belief that the rules can be discovered by careful systemic study. (SC.H.2.4.1)

Health

The student comprehends concepts related to health promotion and disease prevention. The student understands the potential impact of common risk behaviors on the quality of life. (HE.A.1.4.2)

The student understands how the environmental conditions of the community influence the health of individuals. (HE.A.1.4.4)

The student understands how public health policies and government regulations influence health conditions. (HE.A.1.4.7)

The student knows how the prevention and control of health problems are influenced by research and medical advances. (HE.A.1.4.8)

The student knows how to use goal-setting and decision-making skills which enhance health. The student knows how to make positive decisions related to injury, tobacco, nutrition, physical activity, sexuality, and alcohol and other drugs. (HE.C.1.4.5)

7. Bibliography

Ganem, Donald E., M.D., and B. Brett Finlay, Ph.D. "2000 and Beyond: Confronting The Microbe Menace." Howard Hughes Medical Institute Holiday Lectures on Science, Chevy Chase, Maryland, 1999. Lecture summaries, streaming videos, and other materials available at www.hhmi.org.

The following Web sites are referenced in the course of the curriculum:

- tc.unl.edu/nerds/preser/sec/98nerds/aids/aids.htm
- www.accessexcellence.org/MTC/96PT/Share/latta.html
- www.aegis.com/topics/timeline/default.asp
- www.thebody.com/cdc/factv.html
- www.avert.org/historyi.htm
- www.cdc.gov/default.htm
- www.cdc.gov/ncidod/diseases/flu/fluvirus.htm
- www.nih.gov/
- www.pbs.org/wgbh/amex/influenza/
- www.ph.ucla.edu/epi/snow.html
- www.cdc.gov/ncidod/eid/index.htm

8. Appendix

8. Appendix

Simulation II
Student Instructions and Data Sheets

Getting a Disease Is Just a Throw of the Dice

You will be conducting several simulations of an epidemic caused by the spread of a new strain of the flu among a group of unvaccinated people. Each of you starts as a healthy, never-infected individual. You remain healthy unless you get infected by the flu. If you recover from the flu, you will develop immunity to further infections of this strain of the flu.

Many variables can influence the spread of a disease caused by any particular pathogen. Among these variables are the length of time that it is contagious, the ease with which you can catch it (infectivity), and the distance at which you can catch it. In addition, we can also model the lethality of a disease and the susceptibility of subpopulations.

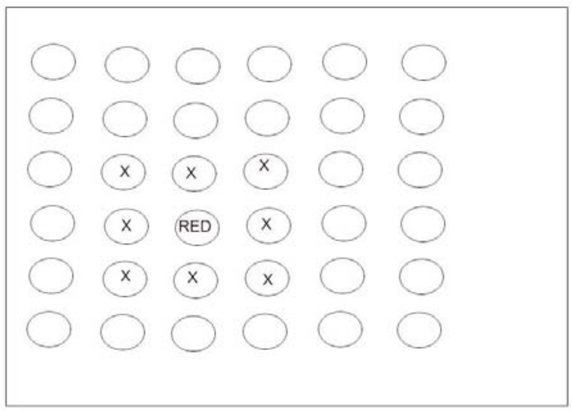
For each simulation, you will collect data and record it in a table in which the rows represent time intervals in the simulation. The total of any given row must equal the total number of people in the class, as long as the flu is not fatal. You'll find your data sheets at the end of this handout.

You have been given a die and three colored cups. The cups let everyone in the class visually follow the spread of the disease. A white cup represents a person who is healthy and never infected. A red cup represents a person sick with the flu. A blue cup represents a person who has recovered and is immune to the flu.

Check under your desk for the red tag of the flu. If you have the red tag, stack your cups so that the outermost one is red. All other students should stack their cups so that the white cup is on the outside.

Simulation I-A

If we assume that a flu is infectious for one cycle and moderately infectious to any desk in contact with an infected individual's desk (all eight desks—see diagram below),



each of you at the desks adjacent to the red cup should roll your die. If you roll a 1 or a 2, sorry—you get the flu and should stack your cup so that red is on the outside. If you roll a 3, 4, 5, or 6, you were lucky enough not to get the flu on this exposure. Keep your white cup on the outside. This flu has an infectivity of 33% (i.e., 1/3 of those exposed get sick).

As a class, count and record the number of sick (red cup) and healthy (white cup) students. Record this as cycle two. After the cycle is completed, the original student with the red cup should restack his/her cup so that the blue cup is on the outside. He/she has recovered and is now immune.

As you begin cycle three, each student adjacent to a desk with a red cup should roll his/her die. Again, if you roll a 1 or a 2, you get the flu and should stack your cup so that red is on the outside. If you roll a 3, 4, 5, or 6, you remain healthy and do not change your cup. If you have a blue cup, you can't catch the flu anymore, even if you are next to someone with a red cup. Don't bother to roll your die!

After you record the class counts, those who turned red during cycle two should restack their cups to show they are recovered (blue).

Continue until most of the class has a blue cup or you reach cycle nine. Record your data on the data sheet each time.

Simulation I-B

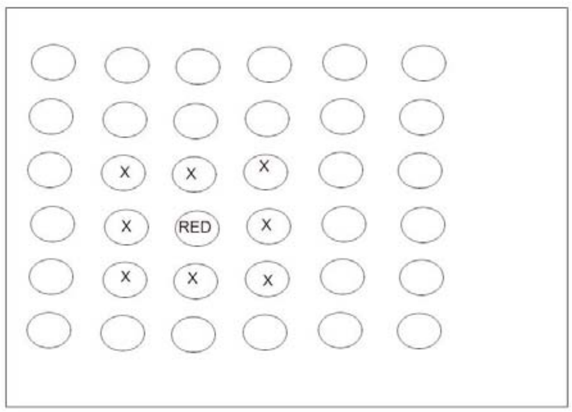
We will repeat the simulation exactly as in I-A except that we will vary the infectivity of the flu, increasing the likelihood that you will get sick on exposure. If you roll a 1, 2, 3, or 4, you will get sick; only a roll of 5 or 6 results in your remaining healthy. This flu has an infectivity of 67% (i.e., 2/3 of those exposed get sick). Observe the spread of the flu (red cups) through the population, being sure to collect and record the data.

Simulation II

We will repeat the simulation. However, in this case, we will examine the effect that length of contagion has on the pattern of epidemic progression. The infectivity will again be set at 67% (i.e., a roll of 1, 2, 3, or 4 means you get the flu, a 5 or 6 means you stay healthy). Once you get the flu, you stay infectious for three cycles. Record the data for simulation II in the data table.

Simulation III

We will repeat the simulation. However, in this case, we will examine the effect that the distance at which the disease is contagious plays in the pattern of epidemic progression. Infectivity will be set at 67% as in I-B and II, the length of time you stay infectious will return to one cycle, as in simulation I-B. The only individuals who can get sick are those in the four desks closest to a sick (red-cup) individual (those next to or immediately in front of or behind an infected person—see diagram below). Be certain you record all the data in the data table.



Simulation Report

Reports should include at least three graphs:

- Graph one should compare the number of individuals in each of the three categories in cases I-A and I-B.
- Graph two should compare the number of individuals in each of the three categories in cases I-B and II.
- Graph three should compare the number of individuals in each of the three categories in cases I-B and III.

In all cases, the x-axis should be the number of cycles (time).

Interpret each graph in light of what you understand about epidemics and your experience with the real flu.

Extensions

Simulation IV

For this simulation we will vary the susceptibility to infection. The dice you were initially given are multicolored. If you have a yellow die, you represent an infant. A white die represents an elderly person. Both infants and the elderly are more susceptible to infection than healthy adults.

As we repeat the simulation, we will return to the basic conditions where all eight adjacent desks are exposed. In this case, however, when you role the die, your disease state will be determined not only by the number on the die, but also by the color of that die.

If you are an infant (yellow die), you get sick if you roll a 1, 2, 3, or 4.

If you are an elderly person (white die), you get sick if you roll a 1, 2, 3, 4, or 5.

If you are a normally healthy adult (all other colors), you get sick if you roll a 1, 2, or 3.

In addition, while healthy adults recover from the flu in one cycle, infants and the elderly remain sick for three cycles.

Again, carefully observe the spread of the disease and record all the data on the data sheet.

Simulation V

This last simulation is similar to simulation IV, except here we will include the possibility of mortality. Once infants or elderly people have the flu, they will continue to roll the die during each cycle before they recover. If they roll a 1, they die. Record all the data in the table.

Data Sheets
I-A

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Data Sheets
I-B

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Data Sheets
II

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Data Sheets
III

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Data Sheets
IV

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Data Sheets

V

Cycles	Flu	Healthy – Never Infected	Healthy – Recovered	Total
1	1			
2				
3				
4				
5				
6				
7				
8				
9				

Simulation III
Student Worksheet

Which Well?

In 1853 outbreaks of cholera, a bacterial disease, killed over 10,000 people in England. Most people believed that "a miasma in the air" caused the epidemics.

Based on that misconception, there was of course no real treatment, prevention, or cure.

In the summer of 1854, a cholera epidemic ravaged the Soho section of London. In only 10 days in late summer, over 500 people died in one small neighborhood.

Dr. John Snow, an anesthesiologist who lived nearby and was familiar with the area, had earlier speculated that cholera was spread by contaminated water. By mapping both the victims and the wells nearby, he showed that the epidemic was centered on one pump, and the single act of removing the pump handle stopped the epidemic.

There is a great deal more to this science adventure story, and if you are interested, you should investigate some of the many Web sites dedicated to this medical hero.

For this assignment you will simulate Dr. Snow's pioneering work. You will plot the position of all the wells in the neighborhood (numbered 1–13) in red on the acetate sheet provided to your group.

Using a black marker, you will then plot a subset of the location of the homes where the victims lived on the same acetate map. Over 500 cholera deaths occurred; each group will only plot 20 to 30 of these locations. Dr. Snow's 1854 map plotted all the deaths. Where multiple deaths occurred in the same house, Dr. Snow stacked the dots perpendicular to the street. Our map does the same thing.

Which pump do you believe was contaminated?

Align your map with that of a neighboring group. Does that improve your prediction?
If so, why?

Turn in your acetate map and have it aligned with all the other maps on an overhead projector.

Which pump was the culprit?