**The Mathematics of an Illness Outbreak**

**Part 1: Disease Simulation Activity** (1 day)

**Materials:**

1. Status cards. Each student should have a set of four status cards, one of each color (green, yellow, pink, blue).
2. Two or three standard six-sided dice.
3. One copy of “Experiment Recording Sheet 1”

**Overview:**

In this simulation, the phases of a disease will be tracked with color coded cards. The colors are used to indicate health status: **green is healthy, yellow is infected, pink is sick, and blue is recovered**.

The simulation consists of a sequence of steps to complete a cycle that represents one day. In a real situation, students would all interact and there would be small chances to pass the disease in each interaction. For a physical simulation, we will instead have just one interaction per day, but with a very large chance of passing the disease. At the beginning one or two students will start with a yellow status card; the remaining students will have green status cards. Then each day/cycle consists of the following steps:

1. Students form pairs.
2. Check for transmission with any pair consisting of one healthy (green) and one either infectious (yellow) or sick (pink). Transmission changes green status to yellow.
3. Advance the time by one day. Anyone who started the day as yellow changes to pink, while pink changes to blue.
4. Record the numbers of each color.

**Procedure (Online classes) (do steps 1-8 before the class starts)**

1. Make sure you have a printed copy of these directions or have an electronic copy on a second computer or tablet.
2. Load the website <https://www.randomlists.com/team-generator> and <https://www.random.org/dice/> in two different browser windows, so that both can be seen at the same time. Also open the recording sheet for the activity.
3. You will be sharing your screen and moving among the three windows. To make the transitions between windows as smooth as possible, resize the windows so that they can all be read with minimal overlap and cover all of most of your screen.
4. **NOTE**: The web pages may contain unrelated advertisements on some computers. *Ignore anything that is not specifically mentioned in these directions!*
5. Set the dice roller to roll 1 virtual die and click the Roll Dice button.
6. Set up the team generator in the lower left quadrant of its window. The Dataset should be set at Team Generator. The number of groups should be half the size of your class, rounded up. Enter the names of your students on separate lines in the Items box with the prefix “G”: for example, “Glenn” should be entered as “G-Glenn” and “Michelle” as “G-Michelle”. The initial G indicates the status of that student (green for healthy). Include yourself if you have an odd number of students so that the number will be twice the number of groups. Click the RERUN button at the bottom and then scroll the window up until the title “Random Team Generator” is at the top. You will see a whole set of groups if your class is not too large or your screen height too small.
7. Share your screen with the class.
8. Summarize or have students read the BITS background on the worksheet. (You may wish to share the worksheet before starting the activity so they can read the background on page 1.)
9. Have your students open the recording sheet on their computers. The students should also have their colored cards in hand with the green card on top.
10. Ask for two volunteers to be “Patients 0”. Change the prefix for each of those students from G to Y to indicate that they are now infected, but not yet sick.
11. Explain the meanings of the card colors. Record the number of students holding green status cards and the number of students holding yellow status cards in column 0 on the BITS. Experiment Recording Sheet 1.
12. Click the Rerun button to the right of the Random Team Generator title. This will regroup the students into new pairs, with the prefix of each making it easy to see each person’s color card.
13. Discuss who is at risk in the various pairs (only healthy people paired with an infectious or sick person).
14. For each person who has a green card that is partnered with a person holding a yellow or pink card, roll one die. If the roll is greater than 1, the person with the green card becomes infected. She changes her status card to yellow while you scroll down to the Items list and change her prefix from “G” to “Y”. If a 1 is rolled on the die, the healthy person does not get infected, so there is no change in status.
15. The two students who started the cycle with yellow status cards exchange them for pink status cards and you change their prefixes from “Y” to “R”. You have now completed one cycle (i.e. one ‘day’).
16. Record the numbers of students holding each color status card at the end of this cycle in column 1 of the BITS Experiment Recording Sheet 1.
17. Complete several more cycles by continuing with the following steps until the pattern of the data becomes apparent:
    1. Click RERUN to generate a new list of student pairs.
    2. Do a separate die roll for each of the students with green cards and yellow or pink partners. If the roll is greater than 1, the student exchanges the green status card for a yellow status card and you change their prefix from “G” to “Y”.
    3. Students who started the cycle with yellow status become pink, and their prefixes change from “Y” to “P”.
    4. Students who started the cycle with pink status become blue, and their prefixes change from “P” to “B”. (Once a student reaches the blue status, they remain blue.
    5. Record the numbers of students holding each color for the current cycle on BITS Experiment Recording Sheet 1.
18. After you have recorded the data for a few cycles, ask students to predict how many people will be in each status category on the next cycle and how they know.
19. Continue taking more turns until nobody has yellow or pink status. At some point during this final phase, pause to ask someone to make a prediction about the outcome: Will everyone get sick?

**Procedure (In-person classes):**

1. Summarize or have students read the BITS background on the worksheet. (You may wish to hand out the worksheet before starting the game so they can read the background on page 1.)
2. Form the students into pairs by arranging half of them in an outer circle (facing inward) and the remaining half in an inner circle (facing outward) so that each student is facing a partner in the other circle.
3. Select two volunteers from the outer circle; choose the volunteers so they are seated on roughly opposite sides of the circle. The two volunteers should display their yellow status card. The remaining students display the green status card. (Note that in a group of 20 – 30 students you will need at least two volunteers; for fewer than 20 you may begin with one.)
4. Explain the meanings of the card colors. Record the number of students holding green status cards and the number of students holding yellow status cards in column 0 on the BITS Experiment Recording Sheet 1.
5. Discuss who is at risk in the various pairs (only healthy people paired with an infectious or sick person).
6. Have each person with a green card that is partnered with a person holding a yellow or pink card roll a die: if the roll is greater than 1, the person with the green card becomes infected and displays the yellow status card. If a 1 is rolled on the die, the person does not get sick, so there is no change in status.
7. The two students who started the cycle with yellow status cards exchange them for pink status cards. You have now completed one cycle (i.e. one ‘day’).
8. Record the numbers of students holding each color status card at the end of this cycle in column 1 of the BITS Experiment Recording Sheet 1.
9. Complete several more cycles by continuing with the following steps until the pattern becomes apparent:
   1. Randomly choose a number from 1-3. Shift everyone in the inner circle that number of spaces in a clockwise direction while the outer circle remains in place. Each student is now facing a new partner.
   2. Students with green cards and yellow or pink partners roll a die to determine if they get the disease. If the roll is greater than 1, the student exchanges the green status card for a yellow status card.
   3. Students who started the cycle with yellow status become pink.
   4. Students who started the cycle with pink status become blue. (Once a student reaches the blue status, they remain blue.
   5. Record the numbers of students holding each color for the current cycle on BITS Experiment Recording Sheet 1.
10. After you have recorded the data for a few cycles, ask students to predict how many people will be in each status category and how they know.
11. Continue taking more turns until nobody has yellow or pink status. At some point during this final phase, pause to ask someone to make a prediction about the outcome: Will everyone get sick?

**Discussion:**

Observe any patterns that appear in the data recorded in the BITS Experiment Recording Sheet. Consider some of these questions:

* How many ended up getting sick?
* Why roll a die to decide whether a person gets sick? (Why not just make it automatic?)
* What would change about the game if the type of sickness was less/more contagious?
* (There are additional discussion questions related to the simulation in the worksheet)

If time allows, run through the activity again so that you can compare the results.