INVESTIGATING RANDOM FLOW

INTRODUCTION

Imagine rain falling on a smooth sloping area of the earth's surface. Some of the drops soak into the surface, others evaporate into the atmosphere, and the rest flow along the surface. Each drop moves downslope until it comes to some small obstacle. Will the drop pass to the left or to the right of the obstacle? What if the obstacle is another drop? How a drop moves is not possible to predict. Such unpredictable events are said to be random. However, even random events can produce discernable patterns. In this investigation, you will produce some random flow paths for raindrops.

OBJECTIVES - - Upon completion of this activity, the student should be able to . . .

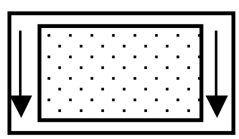
1. Describe how random events can result in an identifiable pattern
2. Predict the pathway followed by a series of raindrops once they fall on a ground surface
3. Formulate a hypothesis to explain raindrop flow patterns generated from random movements
4. Identify large-scale Earth surface features that are similar to the pattern generated in this simulation

STATE STANDARDS ADDRESSED

11.A.4b – Conduct controlled experiments and simulations to test hypotheses
12.D.3a -- Explain and demonstrate how forces affect motion
12.E.3a -- Analyze and explain large-scale dynamic forces, events and processes that affect the earth's land, water, and atmospheric systems.

PROCEDURES

A. Obtain one sheet of graph paper. Select on long edge of the graph paper as the downstream edge. Place this edge nearest to you. On the side (shorter) edges, indicate flow direction by drawing arrows pointing toward the downstream edge of the paper. See the figure below.



Long Edge of Graph Paper

B. Place 40 dots randomly on the sheet of graph paper. Each dot should be located where graph paper grid lines meet. The dots should be spaced fairly uniformly apart, but there should be no order or pattern to them. The dots will represent raindrops that will strike the hillside and then move down the surface.

C. Read this entire section (Procedure C) before actually doing the simulation. This section explains the movement of the simulated raindrops. The movement of the raindrops will be determined by the roll of a die. To move the raindrops, you need to follow these rules:

1. **The Order of Moving Drops:** Each time you move a drop, you will mark its move with a pencil line on the graph paper.

   a. Begin with the dot closest to the top left corner of the graph paper. The second drop to be moved will be the next drop to the right of the first drop, along the same horizontal grid line. The third drop to be moved will be the next drop to the right of the second drop along the same grid line, etc. Once you move the drop farthest to the right edge of the paper, return to the drop closest to the left edge of the paper *on that same grid line* and move it again. Continue moving each of the drops along that same grid line as described above.

   b. In general, upslope dots (those nearest the upslope edge of the graph paper) should be rolled for with the die and moved before dots beneath them are moved.

c. Once all the drops on the topmost grid line have been moved down to the next lower grid line, return to the leftmost drop and move it. Continue for each drop horizontally along this second grid line. Note that the end of the pencil line for a drop is to be treated as a drop. So, if you move down to the second line of the grid, you may come across both line ends and dots (drops). Treat each of these as drops. Once all the drops on this second line of the grid have been moved downslope, go to the left side of the third grid line and repeat the process. Continue this way all the way down the graph paper grid.

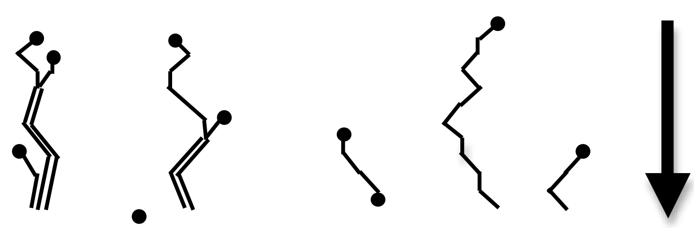
2. **Determining the Direction of Drop Movement:** Before a drop is moved, you will determine its path by the roll of a die. A roll of 1 or 2 on the die will cause the drop to move diagonally to the left. A roll of 3 or 4 will cause the drop to move straight down the slope. A roll of 5 or 6 on the die will cause the drop to move diagonally to the right. Note that the number on the die indicates only the direction of the drop movement, not the distance of movement.

3. **Determining the Distance of Drop Movement:**
   a. When you move a drop after the roll of the die, you will mark the drop's movement by drawing a line one grid space long.

   b. Once a drop or the drop's line intersects another drop or another drop's line, the two will move together as a single larger drop. Its direction will still be determined by the roll of the die. However, its distance will now be twice as far. So, if two drops merge, they will move two grid spaces each time rather than one grid space. Mark the larger drop with a double pencil line to indicate its larger size.

   c. Whenever a drop line intersects any other drop or drop line, you will increase the size of the drop and draw extra pencil lines for it. For example, if three drops merge, then you'll move the drop three spaces at a time, and mark it with three pencil lines.

   d. If a grouping of dots (or a larger drop) moves so that it intersects the path of a smaller drop (or smaller number of drops), the larger group should be moved first and the smaller group should be moved along the larger drop's path. For example, if a three-line drop meets a two-line drop, the two-line drop will change direction to go along the path of the three-drop line. Also, if a three-line drop merges with a two-drop line, the new line will be shown by five lines and will move five spaces at a time. This procedure is necessary to prevent the crossing of streams – something that doesn't occur in nature.



Example of Dot and Line Movement

D. Before you move any dots (raindrops), look at them on the graph paper. Make a prediction about whether or not the dots will create a discernable pattern at the end of the simulation. Write your prediction in the space below. Along with your prediction, explain why you think this will be so.

Prediction about discernable pattern:	

E. Conduct the entire simulation. Be sure to follow the rules specified in Procedure C.

F. Once you have completed the simulation, examine the final result. Write a hypothesis that might explain the results you observe. Write your hypothesis in the space below:

Hypothesis about results:	

DRAINAGE PATTERNS

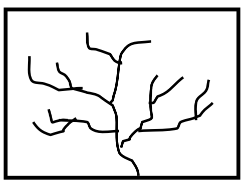


Figure 1: Dendritic

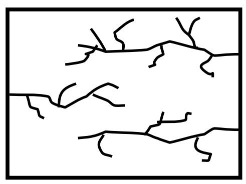


Figure 2: Trellis

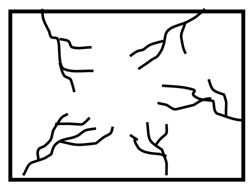


Figure 3: Radial

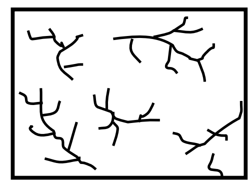


Figure 4: Annular

QUESTIONS

1. Can you predict in advance the direction any single raindrop will move down the slope? Explain your answer.
2. Which of the drainage patterns shown in Figures 1, 2, 3, and 4 matches the pattern produced on the graph paper?
3. What might account for these similarities? (List the things they have in common.)
4. In what ways does the pattern you produced differ from those shown in Figures 1, 2, 3, and 4?
5. Describe the shape of the surface of the land that would produce each of the patterns shown in Figures 1, 2, 3, and 4. (Hints: Water flows downslope, and streams will flow where rocks are least resistant to erosion.)
6. Find some actual Earth surface features that match the results you obtained in this simulation. You may use maps, internet photographs, etc. Provide names for those features, and give their locations on the surface of the earth.
7. For the other three surface drainage patterns shown above (Figures 1-4), find some actual Earth surface features that match the patterns. As for Question 6, you may use maps, internet sources, etc. Provide names for those features and give their locations on the surface of the earth.
8. Explain some ways and give examples of geologic features on the earth's surface that may be created by seemingly-random behaviors of water.

RESOURCE:

American Geologic Institute. (1967). *Investigating the earth*. Boston: Houghton Mifflin Company.