Sec. Name: 

Experiment: Mapping Chromosomes  
(B. Science 10-11-5b)

Purpose: To make a model that simulates crossing-over in order to determine how the frequency of crossing-over can be used to map the positions of genes on chromosomes.

Materials: wooden popsicle stick 
metric ruler 
unlined paper 
pen

Methods: (Step 1 - 3 has been done for you).
1. Using a pen and a ruler, draw a vertical line 15 cm long in the center of a clean sheet of unlined paper. Make a small horizontal mark at the bottom of the line. Measuring from the bottom of the line, add horizontal marks at 1 cm, 3 cm, 6 cm, 10 cm and 15 cm.

2. Label each horizontal line alphabetically (A through F), starting from the bottom.
3. The vertical line on the paper represents a chromosome that has six genes on it - A, B, C, D, E, and F. Color one long edge of the stick. This chromosome's homologous chromosome is represented by the colored edge of the wooden stick.
4. Adjust the sheet of paper so that the bottom edge is about 15 cm from the edge of your lab table. Move your chair back so that the front edge of your seat is about 30 cm from the edge of the lab table.
5. Toss the wooden stick, underhand, toward the vertical line until the stick lands across the line. The landing of the stick across the line represents crossing-over.
6. When crossing-over occurs, look at the colored edge of the stick to determine which genes have been separated. Make a tally mark in the column titled "tallies" in the accompanying data table for each gene that has become separated from gene A. For example, if, as in the figure, the colored edge of the stick lands between D and E, make tally marks for genes E and F because they have both been separated from gene A as a result of crossing-over.
7. Toss the stick and tally the results until crossing-over has occurred 100 times.
8. Count up the number of tally marks for each of the five genes. In the column titled "Number" of the data table, record the number of times each gene was separated from gene A.
9. Calculate the frequency of crossing-over by dividing the number of times each gene was separated from gene A by 100. Record the results of your calculations in the column of the data table entitled, "Frequency of Crossing-Over".
10. Calculate the location of each gene by multiplying the frequency of its crossing-over by 15 and rounding off to the nearest integer. Record the calculated gene locations in the column of the data table entitled, "calculated".
11. Record the measured locations for each gene in the column entitled "Measured". See methods step 1 to find out what the measured distances are between the genes.

Results:

<table>
<thead>
<tr>
<th>Genes that are Separated from Gene A</th>
<th>Times Separated</th>
<th>Frequency of Crossing - Over</th>
<th>Gene Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>from Gene A</td>
<td>Tallies</td>
<td>Number Over</td>
<td>Calculated</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>Measured</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:

1. Did every toss result in crossing-over? Explain.

2. Which gene became separated from gene A most frequently?

3. Which gene became separated from gene A most infrequently?

4. State the relationship between the frequency of gene separation due to crossing-over and the distance between genes, by circling the appropriate word in parenthesis. The greater the distance between the genes, the (lesser, greater) the frequency of gene separation due to crossing over.

5. Are your calculated gene locations exactly the same as the actual gene locations? If so, discuss why the experiment went as expected. If not, discuss possible sources of error.

6. How can the frequencies of crossing-over be used to map chromosomes?

Discussion:

1. Genes A, B, and C are on the same chromosome. Most individuals who are recessive for trait A are also recessive for traits B and C. However, five percent of all those who are recessive for trait A are dominant for trait B, and one percent of all those who are recessive for trait A are dominant for trait C. Starting with Gene A, what is the order of the genes on the chromosome?

2. Why do most individuals with blond hair also have blue eyes? How do exceptions come about?

3. When in the cell cycle and how does crossing-over and recombination occur?