Crossing-Over

Introduction
Ever wonder why, except for identical twins, no two people look exactly alike? While genes determine most of our physical characteristics, the exact combination of genes we inherit, and thus our physical traits, is in part due to a process our chromosomes undergo, known as genetic recombination. Genetic recombination happens during meiosis. Inside the cells that produce sperm and eggs, homologous chromosomes become paired. Homologous chromosomes contain all same genes, but may have different versions of these genes called alleles. For example, in fruit flies the gene for eye color has different versions (alleles) such as red and white. One of the homologous chromosomes is inherited from the mother and the other is passed on from the father. Meiosis separates homologous chromosomes so that the sperm and egg do not contain pairs of chromosomes, rather they contain one copy of every gene, not two. While homologous chromosomes are pressed together during meiosis, they may break, and each may swap a portion of its genetic material for the matching portion from its mate. This form of recombination is called crossing-over. When the chromosomes glue themselves back together and separate, each has picked up new genetic material from the other. Crossing over gives more variation in offspring, because any combination of alleles can be put into a sperm or egg. Alleles on the same chromosome are not necessarily inherited together. The distance between genes on a chromosome affects their crossing over rate. The further apart genes are from each other increases their chance of cross over. The closer genes are, the less likely they are to cross over so they remain on the same chromosome. The genes and the physical characteristics are now different than before crossing-over.

Prelab Questions (answer in your binder)
1. Chromosomes are inherited in pairs, called homologous pairs. How are homologous pairs of chromosomes alike and different?
2. Where does each half of the pair come from? Who passes on each chromosome that makes up the pair.
3. Describe the impact of meiosis on homologous chromosomes.
4. Define crossing over.
**Experimental Question:** How does the distance between genes on a chromosome affect how often they are inherited together?

**Procedure:**

1. Imagine a Fruit fly contains a pair of chromosomes as shown. The Fruit fly has different alleles or versions of genes for each of seven traits, a through g, found on each chromosome.
2. In the figure, the numbers 1 through 6 indicate points where crossing over may occur, thus separating the alleles. For example, if a cross over occurred at point 3, the alleles on chromosome 1 would be ABCdefg, while those on chromosome 2 would be abcDEFG.
3. Roll the die to randomly determine where a cross over will occur. Note the alleles that would remain on the same chromosome as 'a' and record the data in the chart.
4. Repeat step 3 another 99 times (100 cross-overs total)
5. Calculate the percentage of times each allele is found on the same chromosome as "a".

**DATA**

<table>
<thead>
<tr>
<th># of times &quot;a&quot; allele is on the same chromosome as:</th>
<th>% of times &quot;a&quot; allele is on the same chromosome as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>b allele</td>
<td>b allele</td>
</tr>
<tr>
<td>c allele</td>
<td>c allele</td>
</tr>
<tr>
<td>d allele</td>
<td>d allele</td>
</tr>
<tr>
<td>e allele</td>
<td>e allele</td>
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<tr>
<td>f allele</td>
<td>f allele</td>
</tr>
<tr>
<td>g allele</td>
<td>g allele</td>
</tr>
</tbody>
</table>

**Conclusions**

1. Describe the relationship between the probability of two alleles crossing over (separating) and their distance apart on a chromosome. Use your data to support your answer.
2. How does crossing-over cause genetic variation in offspring?
3. Which allele most often remains on the same chromosome as "a"?
4. Which allele is most often separated from "a"?
5. Assume a crossover occurs at point 2. What would be the resulting order of alleles on each chromosome?
6. If a cross-over occurred at point #4, what would be the genes sequence for chromosome #1?
7. Crossing over occurs in what type of cells?

**Extension**

1. How does crossing over help a species tolerate disasters such as disease or climate shift?
2. Evaluate the idea that, “Alleles on the same chromosome are always inherited together because the chromosome is pulled into one sex cell”.