Hemophilia in the royal families of Europe. This partial pedigree traces the sex-linked disease from Queen Victoria through three generations of European dynasties. Queen Victoria had nine children, twenty-six grandchildren, and thirty-four great-grandchildren; only the afflicted individuals and their direct ancestors are shown here.

Hemophilia occurs because the factor (protein antihemophilic factor) is missing. Because of the missing factor, people who have hemophilia can bleed to death from even the smallest cut. Bumps and bruises can cause internal bleeding. Injection of AHF extracted from donated blood can be used to relieve most serious effects of the disease. Many hemophiliacs contracted the AIDS virus in the early 1980s because of the tainted blood transfusions they must receive in order to survive.

With the symbols in mind, the following questions can now be answered.

1. List Queen Victoria's children that are shown on the pedigree.

2. Tell which of her children are carrier females and which are hemophiliac males.

3. Queen Victoria's daughter, Alice, married Louis IV of Hesse, and they had three children. List their children and tell which are carrier females and which are hemophiliac males.
4. Queen Victoria's granddaughter, Alexandra, married Nicholas II, Czar of Russia. Who was their only son? Did he have hemophilia?

5. Queen Victoria's son, Leopold, had one daughter. What was her name? Who did she inherit the gene from? Was she a carrier female?

The next series of questions requires the use of symbols to calculate probabilities or explain how a gene was inherited.

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<thead>
<tr>
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<th>Normal female</th>
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<tr>
<td>X X</td>
<td>Normal female</td>
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<tr>
<td>X X</td>
<td>Carrier female</td>
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<tr>
<td>X Y</td>
<td>Normal male</td>
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<tr>
<td>X Y</td>
<td>Hemophiliac male</td>
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Use Punnett Squares to explain answers to the following questions. Remember Punnett Squares may be used to calculate probabilities of inheritance. Sex-linked traits are handled the same way as nonsex-linked traits.

6. Would it be better for Leopold to have only sons or only daughters?

7. What is the probability that the daughters of Czar Nicholas II of Russia and Alexandra were carriers? (Remember we do not know for sure.)

8. Some of Queen Victoria's children did not have the disease nor were they carriers of the disease. Explain why.
A. Duchenne muscular dystrophy is a deadly disorder in which the muscles grow progressively weaker. The disease is caused by a recessive gene on the X chromosome. The pedigree chart below illustrates the inheritance of this gene. Use the chart to answer the questions that follow.

1. Is Duchenne muscular dystrophy more likely to occur in males or females? Explain your answer.

2. Individual H is a female with this disorder. Explain how she inherited this disease.

3. Individual K has this disorder, yet his father did not. Explain how this is genetically possible.

4. Individual G does not have the disease, yet his mother was a carrier and his father had the disease. Explain how this is possible.
5. Why is the genotype of the father unimportant when investigating sex-linked traits inherited by male offspring?

B. Huntington disease, a disease of the nervous system, is caused by an autosomal dominant gene. The pedigree chart below illustrates a family with individuals who have Huntington disease. Use the chart to answer the questions that follow.

Key:
- Female
- Male
- Huntington disease
- Normal gene

6. What is the probable genotype of individual D? Explain your answer.

7. What are the probable genotypes of individuals H and I? Explain your answer.

8. What is the probability that N will not have Huntington disease?

9. Which individuals can be determined to have Huntington disease?

10. Identify the individuals whose genotypes cannot be determined without more information.