Problem 1
Two mothers give birth to sons at the same time in a busy urban hospital. The son of couple #1 is afflicted with hemophilia A, a recessive X-linked disease. Neither parent has the disease. Couple #2 have a normal son despite the fact that the father has hemophilia A. The two couples sue the hospital in court claiming that a careless doctor swapped their babies at birth. You appear in court as an expert witness. What do you tell the jury?

Problem 2
A male mouse with defective toenails is mated to a female from a true-breeding normal line. In the F1 generation, all of the mice have normal toenails. F1 females are then mated to F1 males.

a. If the toenail phenotype is controlled by a single Mendelian autosomal gene, what is the expected:
   (i) genotypic ratio for F2 females?
   (ii) phenotypic ratio for F2 females?
   (iii) genotypic ratio for F2 males?
   (iv) phenotypic ratio for F2 males?
   (v) phenotypic ratio for all F2 progeny combined?

b. If the toenail phenotype is controlled by a single X-linked gene, (Use $X^T$ for normal toenails, $X^t$ for defective toenails, and $Y$ for $Y$), what is the expected
   (i) genotypic ratio for F2 females?
   (ii) phenotypic ratio for F2 females?
   (iii) genotypic ratio for F2 males?
   (iv) phenotypic ratio for F2 males?
   (v) phenotypic ratio for all F2 progeny combined?
   (you can expect 50% female and 50% male progeny).

What conclusion can you draw about how the predicted outcomes will differ depending on whether a gene is autosomal or sex linked?

Problem 3
A male rabbit with a brittle bones phenotype is mated to a normal female rabbit. All of the F1 progeny are normal. F1 males are crossed to F1 females. In the F2, the following progeny are obtained: 20 normal females, 0 females with brittle bones, 9 normal males, 10 males with brittle bones. Choose appropriate symbols and explain these results by diagraming the genotypes of the crosses.

Problem 4
A male rabbit with a jittery phenotype is mated to a normal female rabbit. In the F1 generation, all of the females are jittery and all of the males are normal.
F1 females are crossed to F1 males. In the F2, the following results are obtained: 10 jittery females, 11 normal females, 11 jittery males, 10 normal males. Assume that the gene for the jittery phenotype is X-linked. Determine whether the jittery phenotype is dominant or recessive. Choose appropriate symbols and diagram the crosses that gave rise to these results.

Problem 5
A Drosophila female is heterozygous for the X-linked recessive vermilion (eye color) mutation. She is also heterozygous for the autosomal recessive droopy mutation. She is mated to a male with wild-type eye color, who is also heterozygous for droopy.

a. What will be the phenotypes of their progeny?
b. If they have 400 progeny, (200 females, 200 males), how may of each phenotype are predicted?

Problem 6
Two phenotypically wild-type insects (“black” and “shiny”) are crossed, and two mutant phenotypes (“blue” and “dull”) are seen to segregate among the progeny as follows:

<table>
<thead>
<tr>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>333 wild-type (black shiny)</td>
<td>665 wild-type (black shiny)</td>
</tr>
<tr>
<td>330 black dull</td>
<td>222 blue shiny</td>
</tr>
<tr>
<td>111 blue shiny</td>
<td></td>
</tr>
<tr>
<td>110 blue dull</td>
<td></td>
</tr>
</tbody>
</table>

For each gene, determine whether it is autosomal or sex-linked, and which allele is dominant. Choose appropriate genetic symbols, give the genotypes of the parents, and show what gemetes thy would produce and how this would give rise to the observed phenotypic ratio.
Problem 7
Male housecats are either black or orange; females are black, tortoise-shell pattern, or orange.

a. If these colors are governed by a sex-linked gene, how can these observations be explained?

b. Using appropriate symbols, determine the phenotypes expected in the progeny of a cross between an orange female and a black male.

c. Repeat part b for the reciprocal of the cross described there.

d. One-half of the females produced by a certain kind of mating are tortoise-shell, and one-half are black; one-half of the males are orange, and one-half are black. What colors are the parental males and females in this kind of mating?

e. Another kind of mating produces progeny in the following proportions: 1/4 orange males, 1/4 orange females, 1/4 black males, and 1/4 tortoise-shell females. What colors are the parental males and females in this kind of mating?

Problem 8
Women who were known to be carriers of the X-linked, recessive, hemophilia gene were studied in order to determine the amount of time required for the blood clotting reaction. It was found that the time required for clotting was extremely variable from individual to individual. The values obtained ranged from normal clotting time at one extreme all the way to clinical hemophilia at the other extreme. What is the probable explanation for these findings?
Problem 9
The Invisible Man’s household: Henry is a product of a long pedigree of invisible personages, whereas Doris, his wife, is from an equally long pedigree of visible personages. (How Doris found Henry is another interesting story relating to non-assortative mate selection. But I digress.) Anyway, they have produced a number of children, two of whom are shown here. They have eighteen children not shown: nine completely visible sons and nine daughters who resemble the daughter shown in the cartoon, but varying with respect to which body parts are visible and which body parts are invisible and the overall extent of visibility.

Part A: Fully explain the inheritance of the visible/invisible phenotype. Include genotypes where useful and be sure to explain all of the information given above, including the variable expressivity in the daughters.

Part B: The phenotype of one of the children should not fit easily into your answer without some additional explanation. Identify the child, fully explain his phenotype and genotype and how it was generated and then suggest the simplest test to confirm your explanation. If any abnormal events are involved be sure to explain where and how, etc.
**Problem 10**
The genes controlling colorblindness and hemophilia are located on the X chromosome 10 map units apart. Study the following pedigree and determine the probability that male III 1 will be:

a. completely normal  
b. colorblind  
c. a hemophiliac  
d. both colorblind and a hemophiliac

![Pedigree Diagram]

**Problem 11**
Duchenne's muscular dystrophy is sex-linked and therefore usually affects only males. Victims of the disease become progressively weaker, starting early in life.

a. What is the probability that a woman whose brother has Duchenne's disease will have an affected child?  
b. If your mother's brother (your uncle) had Duchenne's disease, what is the probability that you have received the gene?  
c. If your father's brother had the disease, what is the probability that you have received the gene?
Problem 12

Two phenotypically wild-type Drosophila (with long wings and red eyes) are crossed, and two mutant phenotypes (curved wings and lozenge eyes) are seen to segregate among the progeny as follows:

<table>
<thead>
<tr>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 long-wing, red eyes</td>
<td>300 long wing, red eyes</td>
</tr>
<tr>
<td>200 curved wing, red eyes</td>
<td>300 long wing, lozenge eyes</td>
</tr>
<tr>
<td></td>
<td>100 curved wing, red eyes</td>
</tr>
<tr>
<td></td>
<td>100 curved wing, lozenge eyes</td>
</tr>
</tbody>
</table>

(i). The curved wing mutation is:  
   a. autosomal recessive  
   b. autosomal dominant  
   c. sex-linked recessive  
   d. sex-linked dominant

(ii). The lozenge eye mutation is:  
   a. autosomal recessive  
   b. autosomal dominant  
   c. sex-linked recessive  
   d. sex-linked dominant

(iii). The female parent is:  
   a. heterozygous for both genes  
   b. heterozygous for the wing gene and homozygous for the eye gene  
   c. homozygous for the wing gene and heterozygous for the eye gene  
   d. none of the above

(iv). The male parent is:  
   a. hemizygous for both genes  
   b. hemizygous for the wing gene and heterozygous for the eye gene  
   c. heterozygous for both genes  
   d. heterozygous for the wing gene and hemizygous for the dominant allele of the eye gene  
   e. heterozygous for the wing gene and hemizygous for the recessive allele of the eye gene.