SEX DETERMINATION AND SEX LINKAGE

INTRODUCTION:

It is known that the human chromosomal set contains 46 chromosomes. One pair of chromosomes of the set is different and the members of this pair have been designated as sex chromosomes. They are alike in females but are unlike in appearance in males. The two which are identical in the female are the same as one of the members of the pair of sex chromosomes in the male. The sex chromosomes in the female are designed as X chromosomes. The female, therefore, has two X chromosomes and is designated as XX. The male has one X chromosome and the other sex chromosome is labeled Y. Genetically, he is characterized XY.

A human male therefore has 22 pairs of chromosomes plus an X and a Y chromosome. The 22 pairs which are not sex chromosomes are called autosomes. The female has two X chromosomes and 22 autosomal pairs.

During meiosis, each sperm cell received one sex chromosome—so that half of the sperm cells will contain an X chromosome and half will contain a Y chromosome. The eggs produced by the female during oogenesis will contain only one X chromosome. The male can produce two kinds of gametes—gametes containing X chromosomes and gametes containing Y chromosomes. The female produces gametes containing only X chromosomes.

Fertilization of an egg by a sperm containing a Y chromosome will produce a male, while fertilization of an egg by a sperm containing an X chromosome will produce a female. Sex therefore is determined at the time of fertilization.

Mammals, fruit flies and other insects exhibit the XX, XY type of determination. However, certain fish and fowl exhibit a reverse type. Instead of the females having the like sex chromosomes, the male exhibits the like pair, the female exhibits the unlike pair. This like pair, exhibited in the male chicken, is designed as ZZ, and the unlike pair is designated as ZW.

In some species of fish the Y chromosome is absent. The male, instead of being XY, is now designated as XO. The O indicates an absence of the chromosome. The female is still XX. This means that the male has one less chromosome in one-half of the gametes that he produces. If the 2n number of chromosomes in a particular individual that exhibits this type of sex determination is 36, the male will contain 18 chromosomes, one of which is an X chromosome, while the other half will contain 17 chromosomes, since there is an absence of a Y. The female will produce eggs having an X chromosome plus 17 autosomes making a total of 18 chromosomes.

The absence of the W chromosome is also exhibited in some chickens, birds, and moths. Instead of the female being ZW, she is ZO and the male is ZZ. Half of the female gametes will have one less chromosome than the other half. All the male gametes will have the usual haploid number.

Genes which are carried on the X or Y chromosomes are called sex-linked genes. There are a number of examples of such genes in man. The gene for color-blindness, for example, is recessive and is located on the X chromosome,therefore being designated as a sex-linked gene. The same is true for the gene for hemophilia. It too is recessive and carried on the X chromosome and the allele is not located on the Y chromosome. The male, since he has only one X chromosome, will carry only one gene for color-blindness. The genotype for a colorblind male is therefore cY since the Y does not carry the allelic gene. A normal-visioned male is CY. He cannot be homozygous or heterozygous since the Y chromosome does not carry an allele for the gene C.

The female carries two genes for color vision since she has two X chromosomes. The genetype of a colorblind female is cc; a normal-visioned female would be Cc or CC.

Genes carried on the Z chromosomes in some chickens or birds may be either dominant or recessive. A classic example of a trait controlled by a gene located on the Z chromosomes in chickens is barring. This gene is dominant and the male has two Z chromosomes each of which carries a gene for the trait. The female may be either BO or bO. The W chromosome does not carry the allele for the gene on the Z chromosomes.

Examples of traits in man controlled by genes on the Y chromosome are few. Since the Y chromosome is carried by males, then only the male offspring will exhibit the Y-linked trait.

QUESTIONS:

1. A pedigree chart of the royal families of Europe showing the transmission of the gene for hemophilia is shown. The gene is thought to have mutated in Queen Victoria's father. Study the pedigree and draw several conclusions regarding the inheritance of this condition. Is it more prevalent in males or females? When the women are normal, can they pass the condition to their sons? Explain. the circles represent females; the squares males. The shaded individuals have hemophilia.

2. What proportion of human beings receive:

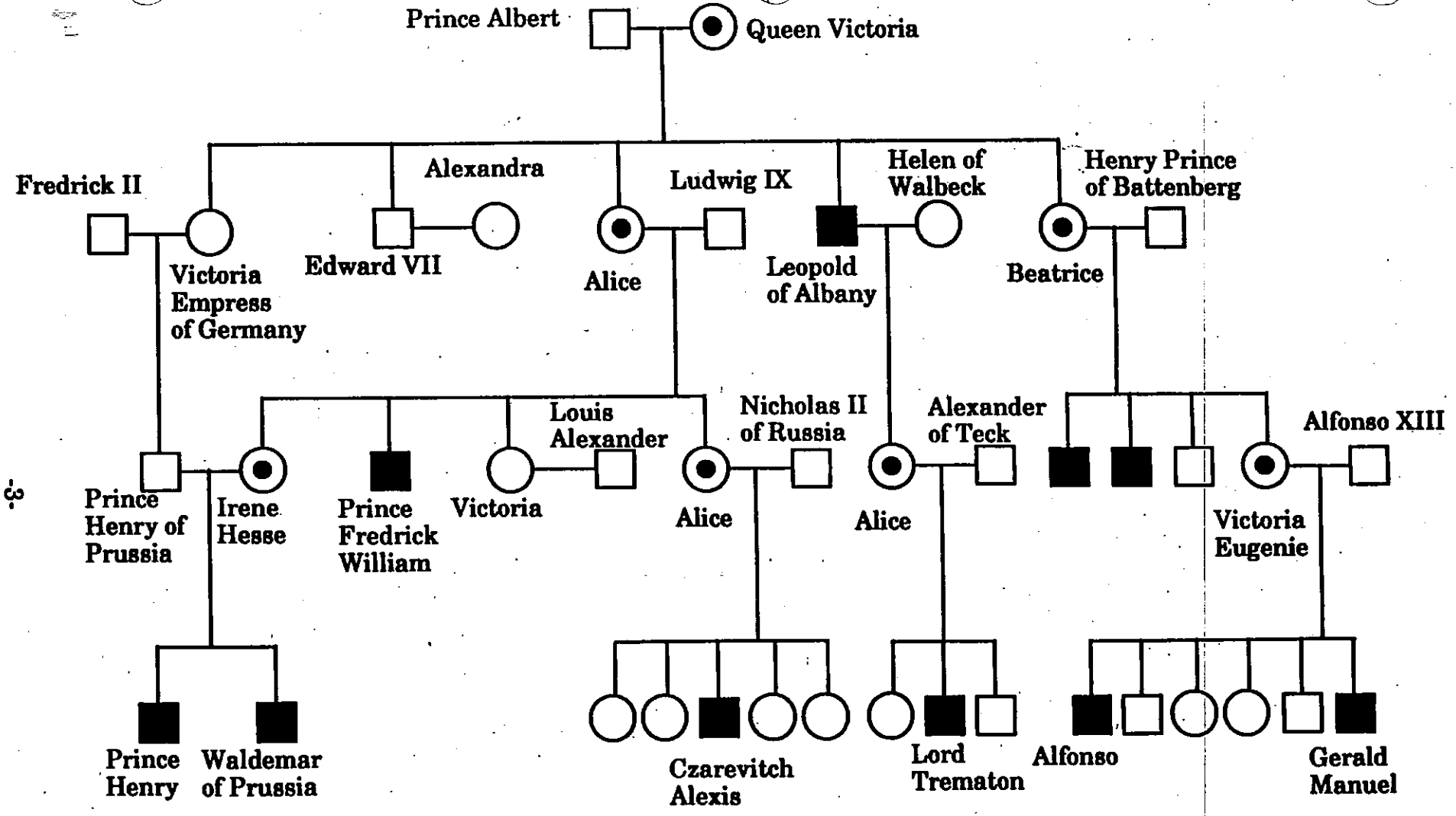
   a. An X chromosome from the father?

   b. An X chromosome from the mother?

   c. A Y chromosome from the father?

   d. An X or Y chromosome from the father?

   e. Two X chromosomes from the mother?



Pedigree of Hemophilia in the Decendants of Queen Victoria

3. If a human male and female produce children, what proportion of their offspring should be males? What proportion should be females? Illustrate using a Punnett square.

4. What conditions are necessary in order for colorblindness to appear in women?

5. Normal vision (C) in man is dominant to colorblindness (c) and is sex-linked. A normal-visioned man, whose father was colorblind, marries a colorblind woman. What are the chances that a son will be colorblind. A daughter? Explain.

6. Hemophilia is due to a sex-linked recessive gene (h) and the normal condition to the gene (H). A hemophilic man marries a woman who is not. Their first son has hemophilia. What are the chances that their daughter, if they have one, will be hemophilic?

7. The "Porcupine Men" who appeared in England during the 18th and 19th centuries had their whole body, except the palms, soles and head, covered with cylindrical bristle-like outgrowths nearly an inch long. The condition appeared when the child was seven or eight weeks old. Judging from the accompanying pedigree, what type of inheritance is involved?

NOTE: Circles represent females and squares males. The individuals who are shaded have the trait.