Name _____ Date _____

Sex-Linked Or Not Sex-Linked?

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An inherited form of muscular dystrophy results in death due to a wasting away of skeletal muscles. The dominant normal gene is represented by the letter *M*. The recessive gene is represented by *m*. How is the trait inherited? Is it a sex-linked genetic disease or not? If it is sex-linked, the gene is located on the X chromosomes. If it is not sex-linked, the gene is located on a chromosomal pair other than the sex chromosomes.

In this investigation, you will

(a) mark coins to represent genes and chromosomes in gamete cells of human males and females.
(b) toss two coins together to simulate the offspring observed if muscular dystrophy is sex-linked.
(c) toss four coins together to simulate the offspring observed if muscular dystrophy is not sex-linked.
(d) determine whether or not muscular dystrophy is sex-linked through the analysis of your data and statements supplied by a hospital.

Materials

adhesive tape
pennies—2
nickels—2
pencil

Procedure

Part A. Observed Results If Sex-Linked

If a trait is sex-linked, the genes are located on the X chromosome. A heterozygous female (X^MX^m) has a 50/50 chance that her egg cells will receive either an X^M or an X^m during meiosis. Normal males have genotype X^MY. The chances that their sperm cells will receive either X^M or Y during meiosis are 50/50. You can determine the offspring of the cross $X^MX^m \times X^MY$ by coin tossing.

- Put adhesive tape on two pennies.
- Mark one penny to represent the possible egg cells. Mark one side X^M and the other side X^m.
- Mark the second penny to represent the possible sperm cells. Mark one side X^M and the other side Y.
- Toss both pennies together 48 times. Use slashes (/) to indicate in Table 23-1 the combination that results after each toss.
- Total the results of each genotype and record them in the table.

Part B. Observed Results If Not Sex-Linked

If the trait is not sex-linked, the genes for muscular dystrophy are not attached to the sex chromosomes. Therefore, two pairs of chromosomes are involved in determining sex and the presence or absence of muscular dystrophy. In obtaining observed results by tossing coins, four coins are needed to represent the two chromosome pairs involved in the cross $XXMm \times XYMm$.

- Add tape to a penny and a nickel. NOTE: You may use the pennies from Part A, but they must be re-marked.

- Mark both sides of the penny with an X. Mark one side of the nickel *M* and the other side *m*. These coins represent possible gametes of a heterozygous female.

- Add tape to a second penny and nickel.

- Mark one side of the penny X and the other side Y. Mark one side of the nickel *M* and the other side *m*. These coins represent possible gametes of a heterozygous male.

- Toss the pennies and nickels together onto your desk 48 times. Use slash marks (/) to indicate in Table 23-2 the combination that results after each toss.

- Total the results of each genotype and record them in the table.

TABLE 23-1. RESULTS IF THE TRAIT IS SEX-LINKED

OFFSPRING PHENOTYPE	OFFSPRING GENOTYPE	RESULT OF EACH TOSS	TOTALS OBSERVED
Normal female	X^MX^M or X^MX^m		
Female with muscular dystrophy	X^mX^m		
Normal male	X^MY		
Male with muscular dystrophy	X^mY		

TABLE 23-2. RESULTS IF THE TRAIT IS NOT SEX-LINKED

OFFSPRING PHENOTYPE	OFFSPRING GENOTYPE	RESULTS OF EACH TOSS	TOTALS OBSERVED
Normal female	*XMXM* or *XMXm*		
Female with muscular dystrophy	*XmXm*		
Normal male	*XMYM* or *XMYm*		
Male with muscular dystrophy	*XmYm*		

Analysis

1. (a) If a trait is sex-linked, how many genes for muscular dystrophy must a female inherit to have the disease? _____

   (b) If a trait is sex-linked, how many genes for muscular dystrophy must a male inherit to have the disease? _____

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2. (a) If a trait is not sex-linked, how many genes for muscular dystrophy must a female inherit to have the disease? _____

   (b) If a trait is not sex-linked, how many genes for muscular dystrophy must a male inherit to have the disease? _____

3. (a) How many normal female children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____

   (b) How many normal female children were observed when the trait was considered to be not sex-linked and both parents heterozygous (*Mm*)? _____

   (c) Are the observed results similar in both cases? _____

4. (a) How many diseased female children were observed when this trait was considered to be not sex-linked and both parents heterozygous (*Mm*)? _____

   (b) How many diseased female children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____

   (c) Are the observed results similar in both cases? _____

5. Which inheritance pattern results in no diseased females? _____

6. According to studies from a leading hospital, no female child with muscular dystrophy has ever been reported from a family where the father is normal and the mother is normal but heterozygous. In view of this true statement, which set of your observed data tends to support this statement? (Is the trait probably sex-linked or not?) _____

7. (a) How many normal male children were observed when the trait was considered to be not sex-linked and both parents heterozygous. (*Mm*)? _____

   (b) How many diseased male children were observed when the trait was considered to be not sex-linked? _____

   (c) Are the observed results similar in both cases? _____

8. (a) How many normal male children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____

   (b) How many diseased male children were observed when the trait was considered to be sex-linked?

   _____

   (c) Are the observed results similar in both cases? _____

9. Which inheritance pattern provides about equal numbers of normal and diseased male children?

   _____

10. According to studies from the same hospital as in question 6, male children with muscular dystrophy occur as often as normal male children in families where the fathers are normal and the mothers are heterozygous. In view of this true statement, which of your observed data tends to support this statement? (Is the trait probably sex-linked or not?) _____

11. A woman is color-blind. Her husband has normal color vision. (Color vision is dominant over color-blindness.) They have 12 children. All daughters have normal color vision while all sons are color-blind.
    (a) Do these offspring indicate that color-blindness is sex-linked or that it is not sex-linked?

    _____

    (b) Explain. _____

    _____

12. Hemophilia is a sex-linked disease. Blood clotting is greatly delayed or does not occur in a person with this condition. If you represent the gene for normal blood clotting with the letter *C* (dominant) and the gene for hemophilia with the letter *c* (recessive),
    (a) how would a coin be marked for a homozygous dominant (two dominant genes) female? (Remember, it is sex-linked.) _____
    (b) how would a coin be marked for a male with the disease? (HINT: How many genes does a male have for this trait?) _____
13. Mark two coins as suggested in question 12a and 12b. Flip your two coins together 48 times. Record all combinations that result by constructing a suitable data chart in the space provided. Total all combinations that are observed through coin flips and indicate these totals on your data chart.
14. On a separate paper, write a brief report explaining your recorded data in question 13. Include in the report:
    (a) the genotypes in the cross of the homozygous dominant mother and the hemophiliac father,
    (b) the genotypes of possible eggs and sperms,
    (c) the number of male hemophiliacs as compared to the normal males that result in the offspring,
    (d) the number of female hemophiliacs as compared to the normal females that result in the offspring,
    (e) the number of hemophiliac offspring as compared to normal offspring, and
    (f) the number of heterozygous females as compared to homozygous females in the offspring.
15. Draw a pedigree in the space below showing the cross in 14a and the possible offspring. You may need to review Investigation 20 for information about the symbols to use.