

Sex-Linked Traits

Name: _____

Date: _____ Score: ____ / 27

Key ideas

Sex chromosomes: females XX, males XY. Sons get their X from their mother and Y from their father; daughters get one X from each parent.

X-linked recessive: write alleles as superscripts (X^B , X^b). Males need one recessive allele to show the trait; females need two. Females with one are **carriers**.

X-linked dominant: an affected father passes it to all daughters and no sons. **Y-linked:** passes from father to every son.

A Sex determination3 marks

1. Which parent determines the sex of a child? Explain.
-
2. What is the probability that a child will be a girl? Show it with the Punnett square.

Offspring:

P(girl):

3. Which gene on the Y chromosome switches on male development?
-

B Writing sex-linked genotypes4 marks

Colour blindness: X^B = normal vision, X^b = colour-blind. ½ mark each.

	Phenotype	Genotype
4.	Male with normal vision	
5.	Colour-blind male	
6.	Female with normal vision (not a carrier)	
7.	Carrier female	
8.	Colour-blind female	
9.	Carrier male (write "not possible" if it cannot exist)	

10. Why can a female be a carrier of colour blindness but a male cannot?
-

C X-linked recessive crosses

8 marks

Complete each Punnett square and answer the question. 2 marks each.

11. Colour blindness is X-linked recessive. A carrier woman has children with a colour-blind man. What fraction of their **daughters** will be colour-blind?

Parents:

Offspring:

Daughters colour-blind:

12. Haemophilia is X-linked recessive. A woman who is not a carrier has children with a man who has haemophilia. Describe the sons and daughters.

Parents:

Offspring:

Result:

13. Duchenne muscular dystrophy (DMD) is X-linked recessive. A carrier mother and an unaffected father have a child. What is the probability the child is a son with DMD?

Parents:

Offspring:

Probability:

14. Thomas Morgan crossed a white-eyed female fruit fly with a red-eyed male. Red (X^R) is dominant to white (X^r). Describe the offspring.

Parents:

Offspring:

Result:

D X-linked dominant and Y-linked traits

4 marks

15. Hypophosphatemic rickets is X-linked dominant (X^A = affected). An affected man has children with an unaffected woman. Describe the offspring. (2 marks)

Parents:

Offspring:

16. Why does a father with an X-linked dominant trait never pass it to his sons?

17. A trait is Y-linked. Which children of an affected father will have it?

E One autosomal gene + one X-linked gene

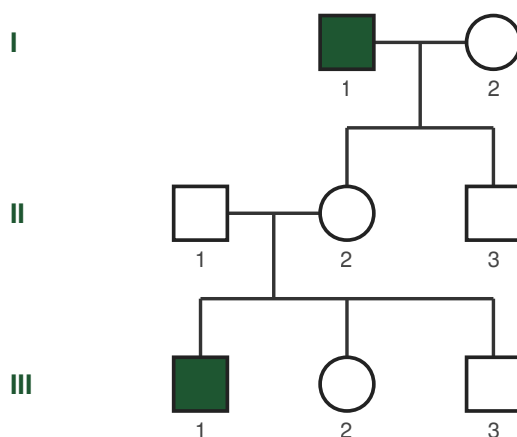
3 marks

18. In fruit flies, red eyes (X^R) are dominant to white eyes (X^r), and normal wings (V) are dominant to vestigial wings (v) on an autosome. A VvX^RX^r female is crossed with a vvX^rY male. What is the probability of a white-eyed male with vestigial wings? (2 marks)

19. What is the probability of a red-eyed fly with normal wings?

F Reading a pedigree: colour blindness

3 marks



20. II-2 has normal vision. Explain why she *must* be a carrier.

21. I-1 is colour-blind, but his son II-3 is not. Explain.

22. What is the probability that III-2 is a carrier?

G Spot the mistake

2 marks

23. A student says: "A colour-blind man will pass colour blindness on to his sons." Explain the error and correct it.

24. A student says: "Females can't be colour-blind." Explain the error and correct it.

Sex-Linked Traits **ANSWER KEY****Key ideas**

Sex chromosomes: females XX, males XY. Sons get their X from their mother and Y from their father; daughters get one X from each parent.

X-linked recessive: write alleles as superscripts (X^B , X^b). Males need one recessive allele to show the trait; females need two. Females with one are **carriers**.

X-linked dominant: an affected father passes it to all daughters and no sons. **Y-linked:** passes from father to every son.

A Sex determination

3 marks

1. Which parent determines the sex of a child? Explain.

The father. Every egg carries an X, but a sperm carries either an X (girl) or a Y (boy).

2. What is the probability that a child will be a girl? Show it with the Punnett square.

	X	Y
X	XX	XY
X	XX	XY

Offspring:

1 girl : 1 boy

P(girl):

1/2

3. Which gene on the Y chromosome switches on male development?

The SRY gene (sex-determining region Y)

B Writing sex-linked genotypes

4 marks

Colour blindness: X^B = normal vision, X^b = colour-blind. ½ mark each.

	Phenotype	Genotype
4.	Male with normal vision	X^BY
5.	Colour-blind male	X^bY
6.	Female with normal vision (not a carrier)	X^BX^B
7.	Carrier female	X^BX^b
8.	Colour-blind female	X^bX^b
9.	Carrier male (write "not possible" if it cannot exist)	Not possible: a male has only one X

10. Why can a female be a carrier of colour blindness but a male cannot?

Females have two X chromosomes, so a normal allele can hide a recessive one. Males have only one X, so any recessive allele on it is expressed.

C X-linked recessive crosses

8 marks

Complete each Punnett square and answer the question. 2 marks each.

11. Colour blindness is X-linked recessive. A carrier woman has children with a colour-blind man. What fraction of their **daughters** will be colour-blind?

	X^b	Y
X^B	X^BX^b	X^BY
X^b	X^bX^b	X^bY

Parents:

 $X^BX^b \times X^bY$

Offspring:

1 carrier daughter : 1 colour-blind daughter : 1 normal son : 1 colour-blind son

Daughters colour-blind: 1/2

12. Haemophilia is X-linked recessive. A woman who is not a carrier has children with a man who has haemophilia. Describe the sons and daughters.

	X^h	Y
X^H	$X^H X^h$	$X^H Y$
X^H	$X^H X^h$	$X^H Y$

Parents:

$$X^H X^H \times X^h Y$$

Offspring:

1 carrier daughter : 1 normal son

Result:

All daughters are carriers; all sons are unaffected

13. Duchenne muscular dystrophy (DMD) is X-linked recessive. A carrier mother and an unaffected father have a child. What is the probability the child is a son with DMD?

	X^D	Y
X^D	$X^D X^D$	$X^D Y$
X^d	$X^D X^d$	$X^d Y$

Parents:

$$X^D X^d \times X^D Y$$

Offspring:

1 normal daughter : 1 carrier daughter : 1 normal son : 1 DMD son

Probability:

1/4 (and 1/2 of sons)

14. Thomas Morgan crossed a white-eyed female fruit fly with a red-eyed male. Red (X^R) is dominant to white (X^r). Describe the offspring.

	X^R	Y
X^r	$X^R X^r$	$X^r Y$
X^r	$X^R X^r$	$X^r Y$

Parents:

$$X^r X^r \times X^R Y$$

Offspring:

1 red-eyed female : 1 white-eyed male

Result:

All females red-eyed (carriers); all males white-eyed

D X-linked dominant and Y-linked traits

4 marks

15. Hypophosphatemic rickets is X-linked dominant (X^A = affected). An affected man has children with an unaffected woman. Describe the offspring. (2 marks)

	X^A	Y
X^a	$X^A X^a$	$X^a Y$
X^a	$X^A X^a$	$X^a Y$

Parents:

$$X^A X^a \times X^A Y$$

Offspring:

1 affected daughter : 1 unaffected son

16. Why does a father with an X-linked dominant trait never pass it to his sons?

Sons inherit their father's Y chromosome, not his X.

17. A trait is Y-linked. Which children of an affected father will have it?

All sons and no daughters, because every son gets his father's Y.

E One autosomal gene + one X-linked gene

3 marks

18. In fruit flies, red eyes (X^R) are dominant to white eyes (X^r), and normal wings (V) are dominant to vestigial wings (v) on an autosome. A $V v X^R X^r$ female is crossed with a $v v X^r Y$ male. What is the probability of a white-eyed male with vestigial wings? (2 marks)

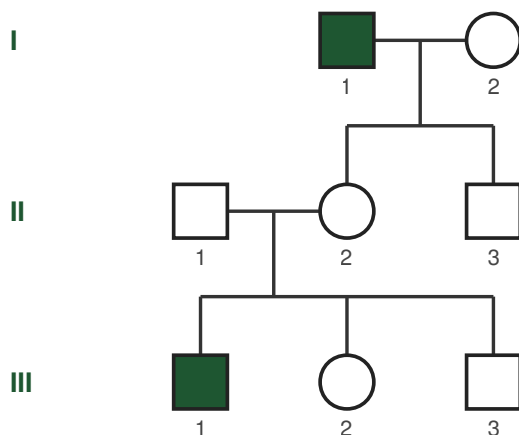
$$P(vv) \times P(X^r Y) = 1/2 \times 1/4 = 1/8$$

19. What is the probability of a red-eyed fly with normal wings?

$$P(Vv) \times P(\text{red-eyed}) = 1/2 \times 1/2 = 1/4 \text{ (red-eyed offspring are } X^R X^r \text{ females or } X^R Y \text{ males)}$$

F Reading a pedigree: colour blindness

3 marks



20. II-2 has normal vision. Explain why she *must* be a carrier.
Her father (I-1) is colour-blind (X^bY) and every daughter gets her father's X, so she is X^BX^b .
21. I-1 is colour-blind, but his son II-3 is not. Explain.
II-3 got his Y from his father and his X from his mother, who passed on X^B .
22. What is the probability that III-2 is a carrier?
Her mother is X^BX^b and her father X^BY : 1/2

G Spot the mistake

2 marks

23. A student says: "A colour-blind man will pass colour blindness on to his sons." Explain the error and correct it.
Sons get their father's Y, not his X, so he cannot pass an X-linked trait to his sons. All his daughters will be carriers.
24. A student says: "Females can't be colour-blind." Explain the error and correct it.
They can if they inherit two recessive alleles (X^bX^b), e.g. from a colour-blind father and a carrier mother. It is just much rarer.