

Practice Problems:

The following questions and comments should help you to understand genetics. Since the genes are on chromosomes it is imperative that you understand the process of meiosis. It will help to make Punnett squares as you work through the various problems. **To make this easier you can print out a sheet with blank Punnett squares from our website.**

Q1) Generate a Punnett Square for a heterozygous individual (a+/a) crossed with a heterozygous individual (a+/a). In this case the mutation is recessive. Determine the genotypic ratio and phenotypic ratio. For phenotypic ratio do not refer to specific a+ or a phenotype but instead refer to them as dominant or recessive. Can this trait be sex linked in humans?

Q2) Generate a Punnett Square for a heterozygous individual crossed with a heterozygous individual. Make the mutation dominant. Notice that the phenotypic ratio for dominant/recessive is identical to 1 (3/4 Dominant, 1/4 recessive) except you now have to realize your mutation is Dominant and wild type is recessive.

Q3) Generate a Punnett Square for a heterozygous individual crossed with a homozygous recessive individual. Make the mutation recessive. Determine the genotypic ratio and phenotypic ratio. Can this trait be sex linked in humans?

Q4) Generate a Punnett Square for a heterozygous individual crossed with a homozygous dominant individual. Make the mutation recessive. Determine the genotypic ratio and phenotypic ratio. Can this trait be sex linked in humans? How does your answer compare to 3?

Q5) Generate a Punnett Square for a homozygous recessive individual crossed with a homozygous recessive individual. Determine the genotypic ratio and phenotypic ratio. Can this trait be sex linked in humans? How does your answer compare to 3?

Q6) Generate a Punnett Square for a homozygous dominant individual crossed with a homozygous dominant individual. Determine the genotypic ratio and phenotypic ratio. Can this trait be sex linked in humans? How does your answer compare to 5?

Q7) Generate a Punnett Square for a homozygous dominant individual crossed with a homozygous recessive individual. Determine the genotypic ratio and phenotypic ratio. Can this trait be sex linked in humans? How does your answer compare to 5 & 6?

**Commit to memory the phenotypic and genotypic ratios for the crosses below.**

The dominant phenotype is indicated by the letter D and the recessive phenotype is indicated by the letter r.

Table 1: Phenotypic and genotypic ratios for autosomal, single traits

	Phenotypic ratios (D/r)	Genotypic ratios
1) heterozygous w/heterozygous	3:1 (3/4D:1/4r)	1:2:1
3) heterozygous w/ homozygous recessive	1:1 (1/2D:1/2r)	1:1
4) heterozygous w/ homozygous dominant	1:0 (1D:0r)	1:1
5) homozygous recessive w/homo recessive	1r:0D	1:0
6) homo dominant w/homo dominant	1D:0r	1:0
7) homozygous recessive w/homo dominant	1D:0r	1:0

\* For questions 3-7 the mutation was considered recessive. Changing the mutation to dominant will not change the dominant/recessive ratio nor the genotypic ratio. It would change the notation (upper case).

**Practice problems:**

QQ1) How many different gametic genotypes are possible from the diploid genotypes and determine the probability of each.

- a)  $a^+/a$ ;  $b/b$ ,  $c^+/c$ ,  $D/D$
- b)  $AB/ab$  (map distance = 30%).

QQ 2) A zygote with the genotype  $a^+/a$ ;  $b/b$ ,  $cd/c+d^+$  will produce how many different chromosome combinations in the following cell types.

- a) eye cell
- b) liver cell
- c) egg cell

QQ 3) An individual with the genotype:  $a^+/a^+$ ;  $B/B^+$ ;  $c/c^+$ ;  $DE/D+E$  was crossed with an organism with the genotype:  $a^+/a^+$ ;  $B/B$ ;  $c/c$ ;  $DE^+/D+E$ . What percentage of the offspring will have the following:

- a)  $a^+$  phenotype
- b)  $a^+/a$  genotype
- c) B phenotype
- d)  $B/B$  genotype
- e)  $a^+$  and  $B^+$  phenotype
- f)  $a^+/a^+$ ,  $B/B$  genotype
- g)  $D^+$  phenotype (**map distance between D & E = 30%**).
- h) make up several of your own combinations and determine the probability.

QQ 4) A six-fingered man and a five-fingered woman have 20 children (10 males and 10 females) with six-fingers. Do you know if six-fingered is dominant or recessive? Do you know if six-fingered is sex-linked? Do you know with 100% percent certainty that the male is homozygous for six-fingered. What is the probability that if the male is heterozygous for six-fingered that all 20 children are six-fingered?

QQ 5) Two traits are being examined. In the following table, the dominant phenotype is indicated by the letter D and the recessive phenotype is indicated by the letter r.  $D D$  would indicate Dominant for trait 1 and Dominant for trait 2. Likewise,  $r D$  would indicate recessive for trait 1 and Dominant for trait 2. Determine the genotype of the parents that gave rise to these offspring based upon the number of offspring. 7 problems (i to vii) are given. Note that there may be more than one cross that yields these answers, if so try to determine all of them. **IGNORE SEX LINKED FOR ALL OF THESE PROBLEMS.**

	D D	D r	r D	r r
i)	400	400	400	400
ii)	900	300	300	100
iii)	600	600	200	200
iv)	600	200	200	600
v)	200	600	600	200
vi)	1,200	0	0	0
vii)	0	0	0	1,200

General logic: The previous problems ignored the names of the traits to minimize confusion. Note how important it is to determine which traits are dominant and which are recessive. In some crosses you may not be able to determine which is dominant and which is recessive. There aren't many "rules" you can remember when it comes to genetics. There are a few however.

- 1) First determine which traits are you looking at and determine the alleles of each.
- 2) Determine which alleles are dominant or recessive.
- 3) Examine the ratio for each trait SEPARATELY.
- 4) Match the ratio to the genotype for each trait. For example a 3:1 ratio would imply that a heterozygous individual was crossed with a **heterozygous** recessive individual! The dominant allele is the one that is more prevalent (3/4). What would a 1:1 ratio imply for the individuals genotype for the second trait? If you don't know the answer instantly then go back and look at the table on the first page. The table lists the ratios you should commit to memory.
- 5) Now figure out the probability of the two events occurring if they are independent. If the numbers match your predictions then the traits are genetically unlinked. If the numbers don't match then the traits are genetically linked (or maybe you made a mistake, or they may be sex-linked). If the traits are linked then the offspring that are most numerous are due to the fact that they received a parental type of chromosome. (See iv and v on the previous page). Double check this. Look at #8 on the GMB III worksheet.

Application:

QQQ1) A wild-type male fly (normal wings and normal body color) was crossed to a mutant female fly from a true breeding with vestigial wings and ebony body. Based upon the following results can you determine the genotype?

- a)  $1/4$  = wild type for both traits,  $1/4$  = normal wings and ebony body,  $1/4$  = vestigial wings and normal body,  $1/4$  = vestigial wings and ebony body.

QQQ2) Given the following genotypes make a Punnett square for the cross. Be sure to include the genotype and phenotype of each box within your Punnett square. Determine the probability of each box. Now go back and actually list the 4 types of phenotypes (D D; D r; r D; r r and give the percentage of each of the four types.

Ab+/A+b crossed with Ab/Ab. **Map distance = 20.**

Ab+/A+b crossed with ab/ab. **Map distance = 20.**

QQQ3) In humans, normal tooth enamel is white. A mutant allele that is dominant and linked to the X chromosome results in the production of defective tooth enamel that is brown in color. A man with brown tooth enamel marries a woman with normal teeth (no history of brown tooth enamel in her family history). Their daughter marries a man with normal tooth enamel. Answer the following questions.

- a) What is the probability that a son from this couple will have brown teeth?
- b) What is the probability that a son from this couple will have normal teeth?
- c) What is the probability that a daughter from this couple will have brown teeth?
- d) What is the probability that a daughter from this couple will have normal teeth?

QQQ4) An individual is heterozygous for four genes, named a, b, c and d. The mutations are recessive. This individual is test-crossed with another individual who is homozygous recessive for all 4 traits. 1,000 progeny are found as follows:

phenotype	# of progeny
ab <sup>+</sup> c <sup>+</sup> d <sup>+</sup>	42
a <sup>+</sup> bcd	43
a <sup>+</sup> b <sup>+</sup> c <sup>+</sup> d	140
abcd <sup>+</sup>	145
ab <sup>+</sup> cd <sup>+</sup>	6
a <sup>+</sup> bc <sup>+</sup> d	9
a <sup>+</sup> b <sup>+</sup> cd	305
abc <sup>+</sup> d <sup>+</sup>	310

**Which genes, if any, are linked?** Look at each trait independently – note that it should always be about 1:1 for each trait. Thus looking at the a and b loci you should find 1:1:1:1 if they assort independently ( $1/2 \times 1/2$  for each of the 4 phenotypes). Do you see that? If not then they must not assort independently. Repeat for b and c, c and d.

In each case they do not show independent assortment – thus all 4 are genetically linked. **Determine the parental types!**

**BLANK PUNNET SQUARES AND ANSWERS ARE AVAILABLE ON OUR WEBSITE!**