Principles of Biology - Genetics Problems

GAMETE PRODUCTION

1) Which gametes can individuals with each of the following genotypes produce?

a) AA *answer: 1 kind of gamete (A)*

b) aa *answer: 1 kind of gamete (a)*

c) Aa *answer: 2 kinds of gametes (A & a)*

d) AaBB *answer: 2 kinds of gametes (AB & aB)*

e) AaBb *answer: 4 kinds of gametes (AB, Ab, aB & ab)*

SIMPLE MENDELIAN

2) Black fur in guinea pigs is a dominant trait. White fur is the alternative recessive trait. When a true-breeding black guinea pig is crossed to a white one,

a) What fraction of the F_1 offspring is expected to be heterozygous?

answer: 100% will be heterozygous

BB x bb = 100% Bb (F_1 generation)

	B
b	*Bb*

b) What fraction of the F_2 offspring is expected to be heterozygous?

answer: 50% of the F_2 will be heterozygous

The F_1 individuals are all heterozygous (Bb). They can each produce two types of gametes, B & b which can combine with each other during fertilization to form the F_2 individuals (see Punnett square below).

	B	*b*
B	*BB*	*Bb*
b	*Bb*	*bb*

c) What fraction of the black F_2 offspring is expected to be heterozygous?

answer: 2/3 (or 66%) of the black F_2 individuals will be heterozygous

BB and Bb genotypes both would present as a black phenotype. It is twice as likely that a Bb individual will be produced as it is that a BB individual will result from the F_1xF_1 mating. Since you would then expect 2 Bb offspring for every 1 BB offspring that is produced, you can say that 2/3 (or 66%) of the black F_2 individuals will be heterozygous.

3) A couple of black guinea pigs of the same genotype were mated and produced 29 black and 9 white offspring. What you would predict the genotypes of the parents to be?

answer: They would both be heterozygous (Bb)

Hint: Try all combinations of matings with black parents (BB or Bb). Then determine the probability of phenotypes among the offspring.

BB x BB = all BB (all black)
Bb x BB = ½ BB; ½ Bb (all black)
Bb x Bb = ¼ BB; ½ Bb; ¼ bb (3/4 black; ¼ white)

4) Consider a gene with two alleles, B and b.

a) List all the matings (*i.e.*, parental genotypes) that could produce a heterozygous child.

answer: *BB x bb*
Bb x Bb
Bb x bb
BB x Bb

b) Which mating in your list gives the greatest proportion of heterozygous offspring?

answer: *BB x bb (would give 100% Bb)*

The others would result in only 50% Bb:

5) The absence of legs in mice has been attributed to a recessive allele. A normal male is mated with a normal female and they produce a legless offspring. The same two parents are mated again. What is the chance of their next offspring being legless?

answer: If two normal parents produce a homozygous recessive offspring, they must both be heterozygotes (Ll). Since they are both heterozygous, the chance that their next offspring will be legless (ll) is 25%.

	L	*l*
L	*LL (legs)*	*Ll (legs)*
l	*Ll (legs)*	*ll (legless)*

*(**note**: the fact that they already have a legless offspring does not affect the probability of their having a 2^{nd} legless offspring)*

TESTCROSS

6) If a black female guinea pig is test-crossed and produces 2 offspring in each of 3 litters, all of which are black, what is her probable genotype?

answer: She is most likely BB, since all of her offspring from her testcross were black. If she were Bb, then 50% of her offspring should be white.

CODOMINANCE

7) The amount of chlorophyll in snapdragons is controlled by a pair of codominant alleles. Dark green is governed by the genotype: C^1C^1. Light green is governed by the genotype: C^1C^2. White is governed by the genotype C^2C^2.

a) When light green snapdragons are crossed among themselves, what genotypic and phenotypic ratios are expected among their progeny?

answer: $C^1C^2 \times C^1C^2$

	C^1	C^2
C^1	C^1C^1	C^1C^2
C^2	C^1C^2	C^2C^2

Genotypic ratio: ¼ C^1C^1 : ½ C^1C^2 : ¼ C^2C^2
Phenotypic ratio: ¼ dark green: ½ light green: ¼ white

b) If dark green snapdragons are crossed with white snapdragons, what genotypic and phenotypic ratios are expected among their progeny?

answer: $C^1C^1 \times C^2C^2$

	C^1
C^2	C^1C^2

Genotypic ratio: all C^1C^2
Phenotypic ratio: all light green

8) Yellow coat color in guinea pigs is produced by the homozygous genotype C^yC^y, cream color by the heterozygous genotype C^yC^w, and white by the homozygous genotype C^wC^w. What genotypic and phenotypic ratios are matings between cream-colored individuals likely to produce?

answer: $C^yC^w \times C^yC^w$

	C^y	C^w
C^y	C^yC^y	C^yC^w
C^w	C^yC^w	C^wC^w

Genotypic ratio: ¼ C^yC^y : ½ C^yC^w : ¼ C^wC^w
Phenotypic ratio: ¼ yellow: ½ cream: ¼ white

SEX-LINKED

9) In fruit flies the most common eye color is red. A mutation (or allele) of the gene for eye color produces white eyes. The gene is located on the X chromosome.

a) What is the probability that a heterozygous red-eyed female fruit fly mated with a white-eyed male will produce any white-eyed offspring?

Answer: X^+X^w x X^wY

	X^+	X^w
X^w	X^+X^w	X^wX^w
Y	X^+Y	X^wY

X^wX^w and X^wY will both have white eyes, so 50% of the total offspring will be expected to have white eyes.

b) What is the probability that the mating in (a) will produce any white-eyed females?

Answer: 25% of the total offspring are white-eyed females (however, 50% of all females are white-eyed).

c) What is the probability that this same mating will produce any white-eyed males?

Answer: 25% of the offspring are white-eyed males.

10) In fruit flies the most common eye color is red. A mutation (or allele) of the gene for eye color produces white eyes. The gene is located on the X chromosome.

a) What is the probability that a heterozygous red-eyed female fruit fly mated with a red-eyed male will produce any white-eyed offspring?

Answer: X^+X^w x X^+Y

	X^+	X^w
X^+	X^+X^+	X^+X^w
Y	X^+Y	X^wY

Only X^wY will have white eyes, so 25% of the total offspring will be expected to have white eyes.

b) What is the probability that the mating in (a) will produce any white-eyed females?

Answer: There are two genotypes produced among the females. X^+X^w and $X^+X^{w+.}$ Neither of these genotypes would produce a white-eyed phenotype. Therefore, 0% of the offspring will be white-eyed females.

c) What is the probability that this mating will produce any white-eyed males?

Answer: There are two genotypes produced among the males. X^wY and $X^+Y^.$ X^wY males will have white eyes and X^+Y males will have red eyes.

Therefore, 50% of all males and 25% of all offspring will be white-eyed males.

11) A female who is the carrier of color blindness marries a male who is not color blind. Color blindness is a sex-linked trait. What is the probability that any of the offspring produced have the following traits?

	X^c	X
X	X^cX	XX
Y	X^cY	XY

a) color blindness

Answer: There are four possible genotypes for all offspring: X^cY, XY, X^cX; XX. Only the X^cY genotype would have a color blind phenotype. Therefore, 25% of the total offspring would be expected to be color blind.

b) color blind males

Answer: There are two possible genotypes for males: X^cY and XY. Only the X^cY genotype would have a color blind phenotype. Therefore, 50% of the males would be expected to be color blind. (Or 25% of total)

c) color blind females

Answer: There are two possible genotypes for females: X^cX and XX. Neither genotype would present as a color blind phenotype. Therefore, 0% of the females would be expected to be color blind.