CHAPTER 2

Mendel's Laws of Heredity

VOCABULARY

Match the phrases to the terms below. Each term may be used once, more than once, or not at all.

Phrases

1.) An alternative form of a gene at a locus
2.) Describes an allele that needs two copies to be present to produce its phenotype
3.) An example of a disorder caused by a dominant allele
4.) Describes an allele that produces a particular phenotype even when only one copy is present
5.) The genetic constitution of an individual, or the combination of alleles at a particular locus
6.) An example of a disorder caused by a recessive allele
7.) Cell division during which crossing-over occurs
8.) Type of cell division that occurs in ovaries and testes, producing gametes
9.) A basic unit of inheritance, found on a chromosome
10.) Said to be present for genes close together on a chromosome

Terms

allele
amino acid
chromatid
chromosome
dominant
gamete
gene
genotype
Huntington disease
linkage
locus
meiosis
pedigree
phenotype
phenylalanine
phenylketonuria (PKU)
protein
recessive
recombination

Ans:
1.) *allele* 2.) *recessive* 3.) *Huntington disease* 4.) *dominant* 5.) *genotype*
6.) *phenylketonuria* 7.) *meiosis* 8.) *meiosis* 9.) *gene* 10.) *linkage*
Level: E
Topic: Mendel's Laws of Inheritance

Pages: 6–19

PROBLEMS

1. The albino phenotype is an inherited trait that has behavioral consequences in mice. In the offspring of two carrier mice, the Mendelian phenotypic ratio of 3 normal to 1 albino is observed. How many genes does this suggest albinism is controlled by?

   Ans: *one*
   Level: M
   Topic: Mendel's First Law of Heredity
   Pages: 8–10

2. The behavioral **Waltzer phenotype** in mice is characterized by head shaking, rapid circling, and irritability (van Abeelen and van der Kroon, 1967). True-breeding mice are mice that have two similar alleles at the Waltzer locus.

   True-breeding Waltzer males and females, when mated, produce offspring all with the Waltzer phenotype. True-breeding Waltzer females and non-Waltzer males produce all normal offspring. Second generation (F2) results from mating the offspring from a cross between true-breeding Waltzer and non-Waltzer mice are shown below:

Normal (non-Waltzer) mice	124
Waltzer mice	48
TOTAL	172

   a. Do you think the allele for the Waltzer phenotype is dominant or recessive?

   Ans: *recessive*
   Level: E
   Topic: Mendel's First Law of Heredity
   Pages: 7–10

   b. Give your reason why.

   Ans: *Waltzer mice crossed with normal mice produce all normal offspring, and it looks like the ratio of phenotypes in crosses between these offspring (i.e., F2 mice) give normal to Waltzer in the ratio 3:1, as expected from Mendel's First Law.*
   Level: E
   Topic: Mendel's First Law of Heredity
   Pages: 10

   c. Perform a chi-square test to determine if the results given above are consistent with your hypothesis.

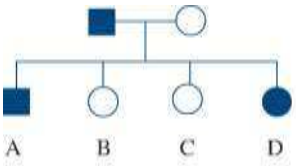
   Ans:
   Hypothesis: If Waltzer is caused by a recessive allele, expect 3:1 normal to Waltzer in F2 generation.
   Chi-square formula $\chi^2 = \sum (obs - exp)^2/exp$

Test	*Obs*	*Exp*	*O-E*	$(O-E)^2$	$(O-E)^2/E$
	124	*129*	*5*	*25*	*0.194*
	48	*43*	*5*	*25*	*0.581*

♦ = 0.775 = χ^2_{1df} ~32% probability

Conclusion: Retain hypothesis; the probability of getting such observed numbers is high.
Level: D
Topic: Mendel's First Law of Heredity
Pages: 8–9

3. The figure below shows a small portion of a Huntington disease pedigree:



a. Using H as the symbol for the Huntington allele and h as the normal allele, give the genotypes at the Huntington locus for each of the four children (A,B,C,D)

Ans: *A = Hh B = hh C = hh D = Hh*
Level: M
Topic: Huntington disease
Pages: 10–11

b. If child B marries an affected man, what is the probability that their first child would develop Huntington disease?

Ans: *0.5 (or 50%)*
Level: M
Topic: Huntington disease
Pages: 10–11

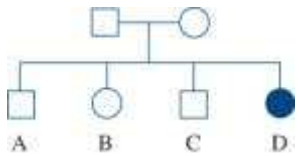
c. If their first child is unaffected, what is the probability that their second child is affected?

Ans: *0.5 (or 50%)*
Level: M
Topic: Huntington disease
Pages: 10–11

d. If child A marries an unaffected woman and has two children, what is the probability that **both** children are unaffected?

Ans: *0.5×0.5 = 0.25*
Level: D
Topic: Huntington disease
Pages: 10–11

4. The figure below shows part of a PKU pedigree:



a. Using K as the symbol for the normal allele and k as the symbol for the PKU allele, give the possible genotypes of the unaffected children (A,B,C).

Ans:
A = KK or Kk B = KK or Kk C= KK or Kk
Level: M
Topic: Phenylketonuria (PKU)
Pages: 11–12

b. Given that child A is an **unaffected** brother of a PKU child, what is the probability that he is a PKU

carrier?

Ans: *0.66 (or 2/3)*
Level: M
Topic: Phenylketonuria (PKU)
Pages: 11–12

c. Assume A is a carrier. What genotype would his mate have to be for a child of the couple to be at risk for PKU?

Ans: *Kk (or kk, but this is less likely)*
Level: E
Topic: Phenylketonuria (PKU)
Pages: 11–12

d. What are A's chances (assuming he is a carrier) of marrying and producing children who are **not** at risk for having PKU? (see Box 2.2, page 13 of text)

Ans: *A cannot marry Kk or kk; mate has to be KK*
Frequency of Kk = 2% Frequency of kk = 1/10000
So, frequency of KK = 1 – (0.2+ 0.00001) = 0.97999 around 98%
Level: D
Topic: Phenylketonuria (PKU)
Pages: 12–13

5. A mouse geneticist discovers two recessive alleles, each of which causes the mice to be deaf when two copies are present.

a. How could the geneticist determine whether the alleles occur at the same locus (i.e., are alleles of the same gene)?

Ans: *Cross mice with two copies of one allele with mice having two copies of the other allele. If offspring are deaf, then the alleles are at the same locus. If none of the mice are deaf, then the alleles are at separate loci.*
Level: D
Topic: Mendel's Second Law of Heredity
Pages: 14–17

b. If it is discovered that the alleles are at different loci, how could the geneticist discover if they were located together on the same chromosome?

Ans: *Do a test for linkage: Cross second-generation offspring (F2) from the mating of mice with both types of deafness and look for a departure from the expected ratio of 9:3:3:1. A lack of recombinants would indicate linkage.*
Level: D
Topic: Mendel's Second Law of Heredity
Pages: 14–17