

UNIT 4: GENETICS & PATTERNS OF INHERITANCE

Problem Set, Punnett Square Analysis & Pedigree Interpretation

Academic Year 2025–2026

Student Name: _____

Date: _____

Period: _____

Instructor: Dr. E. Vance

Total Score: _____ / 50 pts

Grade: _____

Section 1: Fundamental Principles & Terminology (8 Points)

Complete the table below by providing the correct genetic term, symbol notation, or description.

Genetic Term	Definition & Biological Significance	Example Alleles	Phenotype Outcome
Homozygous Dominant	Possesses two identical dominant alleles for a given gene locus.	BB	Dominant Trait
Heterozygous	Possesses two distinct alleles for a single gene locus.	_____	Dominant Trait
Phenotype	_____	Physical Appearance	Observable Trait
Codominance	_____	$I^A I^B$	_____
Recessive Allele	Allele whose phenotype is masked in the presence of a dominant allele.	b	Expressed if bb

Section 2: Monohybrid Inheritance & Punnett Square Analysis (10 Points)

1. **Pod Shape Inheritance in Garden Peas (*Pisum sativum*):** In pea plants, inflated pod shape (I) is completely dominant over constricted pod shape (i). A heterozygous inflated-pod plant is crossed with a homozygous constricted-pod plant.

Monohybrid Cross Punnett Square

Maternal Gametes

I i

Paternal Gametes

i i

Ii	ii
Ii	ii

(a) State parental genotypes:

- Parent 1 (Inflated): _____
- Parent 2 (Constricted): _____

(b) Complete the Punnett Square on the right.

(c) Calculate phenotypic ratio of offspring:
Inflated : Constricted = _____

(d) If 480 offspring seeds are collected, calculate expected count of constricted pod plants:
Expected Count = _____ plants.

2. **Coat Color Genetics in Rex Rabbits:** In Rex rabbits, black coat color (B) is dominant to chinchilla gray (b). A geneticist crosses two black rabbits. The resulting litter consists of 27 black kits and 9 chinchilla gray kits.

(a) Determine parental genotypes and justify your answer using Mendelian ratios.

(b) Perform the necessary Punnett square analysis to support your conclusion.

Deduction & Genetic Proof

Section 3: Dihybrid Inheritance & Independent Assortment (12 Points)

1. ***Drosophila melanogaster* Dihybrid Cross Analysis:** In fruit flies, gray body color (E) is dominant over ebony body (e), and normal wings (V) are dominant over vestigial wings (v). A male fly heterozygous for both traits ($EeVv$) is mated with a female fly also heterozygous for both traits ($EeVv$).

- (a) List the four possible gamete combinations produced by each parent fly:

Gametes: EV Ev eV ev

- (b) Complete the 4x4 Dihybrid Punnett Square below by writing the resulting 4-allele genotype in each cell.

Dihybrid Cross Grid ($EeVv \times EeVv$)									
		Female Gametes ($EeVv$)							
		EV	Ev	eV	ev				
Male Gametes ($EeVv$)	EV	$EEVV$	$EeVv$	$EeVv$	$EeVv$				
	Ev	$EeVv$	$EEvv$	$EeVv$	$EeVv$				
	eV	$EeVv$	$EeVv$	$eeVV$	$eeVv$				
	ev	$EeVv$	$EeVv$	$eeVv$	$eevv$				

- (c) Summarize expected phenotypic counts out of 16 total offspring:

- ✓ Gray Body, Normal Wings: _____ / 16 ✓ Ebony Body, Normal Wings: _____ / 16
 ✓ Gray Body, Vestigial Wings: _____ / 16 ✓ Ebony Body, Vestigial Wings: _____ / 16

- (d) **Meiotic Mechanism:** Explain how the chromosome alignment during **Metaphase I** of meiosis produces independent assortment of unlinked genes.

 Biological Explanation

Section 4: Complex & Non-Mendelian Patterns (10 Points)

1. **Incomplete Dominance in Snapdragons (*Antirrhinum majus*):** Red flower color is governed by allele C^R and white flower color by allele C^W . Heterozygous plants ($C^R C^W$) exhibit pink flowers.

- (a) A pink snapdragon is crossed with a white snapdragon. Determine expected genotypic and phenotypic ratios of offspring.

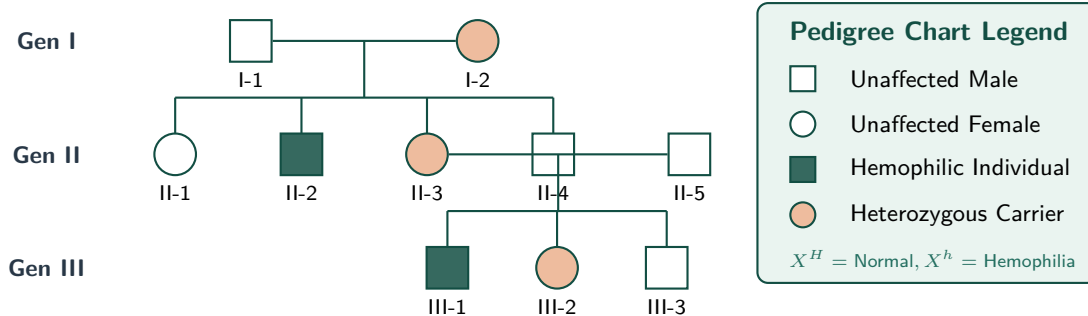
 Snapdragon Cross Work Area

2. **Multiple Alleles & Codominance: Human ABO Blood Types:** Elena (Blood Type A) and Marcus (Blood Type B) have a child, Julian, who has Blood Type O (ii).

- (a) Identify the precise genotypes of Elena: _____ and Marcus: _____.
 (b) What is the probability that their next child will have Blood Type AB? Show your cross.
 (c) **Immunohematology:** Why can an individual with Type O blood safely donate red blood cells to any recipient regardless of blood type?

Section 5: Sex-Linked Inheritance & Pedigree Analysis (10 Points)

The pedigree below traces the inheritance of **Hemophilia A** (an X-linked recessive bleeding disorder caused by a deficiency in Factor VIII) across three generations of the Nexa family.



1. **Genotype Determination:** Assign the most precise genotype for each individual:

- ✂ Individual I-1: _____

✂ Individual II-3: _____

✂ Individual I-2: _____

✂ Individual III-1: _____

✂ Individual II-2: _____

✂ Individual III-2: _____

2. **Probability Calculation:** If Individual III-2 (carrier female) marries an unaffected male (X^HY), calculate the probability of the following outcomes:

- (a) Probability that their first **son** will have hemophilia: _____
- (b) Probability that their first **daughter** will be a carrier: _____
- (c) Overall probability of having an affected child of **any gender**: _____

3. **Genetic Reasoning:** Why are X-linked recessive traits expressed significantly more frequently in males (XY) than in females (XX)?

 X-Linked Inheritance Mechanism

Section 6: Statistical Analysis – Chi-Square (χ^2) Goodness-of-Fit (10 Points)

A research team at **Vertex Genetics Institute** crossed two heterozygous tall, purple-flowered pea plants ($TtPp \times TtPp$). Out of a total sample of **800 offspring plants**, the observed phenotypic distribution was recorded in the table below. Test the null hypothesis (H_0) that the data fits the expected Mendelian **9:3:3:1** dihybrid ratio at a significance level of $p = 0.05$.

Phenotype Category	Observed (<i>O</i>)	Expected Ratio	Expected (<i>E</i>)	$(O - E)^2 / E$
Tall, Purple Flowers	462	9/16	450	$\frac{(462 - 450)^2}{450} = 0.320$
Tall, White Flowers	138	3/16	150	_____
Dwarf, Purple Flowers	154	3/16	150	_____
Dwarf, White Flowers	46	1/16	50	_____
Total Chi-Square Value ($\chi^2 = \sum \frac{(O-E)^2}{E}$):				_____

1. Degrees of freedom ($df = k - 1$): _____ (Critical value at $p = 0.05$ with $df = 3$ is **7.82**).

2. **Conclusion Statement:** Do you accept or reject the Null Hypothesis (H_0)? State your biological rationale.

 Chi-Square Decision & Rationale