Lab 9: Genetics & Inheritance

BIOL-8

Name: ______________________ **Date:** ______________________

Objectives

By the end of this lab, you will be able to:

- Define and correctly use key genetics vocabulary (gene, allele, genotype, phenotype, dominant, recessive, homozygous, heterozygous)
- **Apply the laws of probability** to predict the outcomes of genetic crosses
- **Perform monohybrid crosses** using Punnett squares to determine genotype and phenotype ratios
- **Identify dominant and recessive traits** in yourself and classmates
- **Analyze sex-linked inheritance** and explain why X-linked traits affect males and females differently

Part 1: Background & Key Concepts

Before we begin the hands-on activities, let's review the essential vocabulary and ideas behind inheritance.

What Is Inheritance?

Every living thing inherits its traits from its parents. You got half of your DNA from your biological mother and half from your biological father. The study of how these traits are passed from one generation to the next is called **genetics**. The modern science of genetics was founded by **Gregor Mendel**, who experimented with pea plants in the 1860s.

Key Terminology

Study the following terms carefully. You will use all of them throughout this lab.

Term	Definition
Gene	A segment of DNA that codes for a specific trait (e.g., eye color, blood type)
Allele	A specific version of a gene. For example, the gene for flower color may have a "purple" allele and a "white" allele
Genotype	The combination of alleles an organism carries (written with letters, e.g., *AA*, *Aa*, or *aa*)
Phenotype	The physical, observable expression of a trait (e.g., "purple flowers" or "brown eyes")
Homozygous	Having **two identical** alleles for a trait — either *AA* (homozygous dominant) or *aa* (homozygous recessive)
Heterozygous	Having **two different** alleles for a trait (*Aa*); sometimes called a **carrier** if the trait is recessive
Dominant	An allele whose effect is seen even when only one copy is present. Written as a **capital letter** (e.g., **A**)
Recessive	An allele whose effect is only seen when **two copies** are present. Written as a **lowercase letter** (e.g., **a**)
Carrier	An individual who is heterozygous for a recessive trait — they don't show it but can pass it to offspring
Punnett Square	A grid used to predict the genotype and phenotype ratios of offspring from a genetic cross
Law of Segregation	During gamete (egg/sperm) formation, the two alleles for a gene separate so each gamete carries only *one* allele
Autosomal	A gene located on one of the 22 non-sex chromosomes (chromosomes 1–22)
Sex-linked	A gene located on the **X chromosome**. Males (XY) have only one copy, so they express whatever allele is on their X

Conceptual Review

Answer these questions **before** starting the exercises. Use the terminology table above.

1. If an organism has the genotype *Bb*, is it homozygous or heterozygous?

2. An organism with the genotype *aa* shows the recessive phenotype. What genotype(s) would show the dominant phenotype?

3. A mother and father are both heterozygous (*Aa*). During meiosis, how many alleles does each parent put into a single egg or sperm cell?

4. What is the difference between a genotype and a phenotype? Give a one-sentence example.

5. Why is a heterozygous individual (*Aa*) sometimes called a "carrier" for a recessive trait?

6. If a trait is dominant, does that mean it is the most common in a population? Explain.

Materials

- Two coins (pennies or nickels) per pair of students
- Calculator
- Colored pencils (optional, for dragon drawings)

Safety Considerations

- None. This is a simulation and paper-based lab.

Part 2: The Coin Toss — Probability & Allele Segregation

> ***Learning Goal:*** *Understand how random chance determines which alleles are passed to offspring.*

Sexual reproduction involves chance. During meiosis, the two alleles in a parent separate (segregate), so a parent passes only *one* of their two alleles to each offspring. Which one they pass is random — like flipping a coin.

Procedure

Imagine both parents are **heterozygous (Aa)** for a trait.

- **Heads** = Dominant allele (**A**)
- **Tails** = Recessive allele (**a**)
- **Get two coins.** One represents the **Father (Aa)**, the other represents the **Mother (Aa)**.
- **Flip both coins simultaneously 10 times.**
- Record the combination for each toss in the tally table below.
- **Heads/Heads** = **AA** (Homozygous Dominant)
- **Heads/Tails** or **Tails/Heads** = **Aa** (Heterozygous)
- **Tails/Tails** = **aa** (Homozygous Recessive)

Data Collection

Genotype Tally Sheet (10 Tosses)

#	Genotype	Tally (mark each toss)	Total Count	Percentage (Count ÷ 10 × 100)
1				
2				
3				
4				

Analysis

1. Theoretically, a cross between two heterozygotes (Aa × Aa) should produce 25% AA, 50% Aa, and 25% aa. How close were your results?

2. You only did 10 flips. Do you think your results would be closer to the theoretical percentages if you flipped 100 times? Why?

3. Explain in your own words how this coin flip models what actually happens during meiosis when alleles segregate.

Part 3: Monohybrid Crosses — Albinism in Humans

> ***Learning Goal:*** *Use Punnett squares to predict offspring genotypes and phenotypes for a single trait.*

Albinism (lack of skin pigment) is an **autosomal recessive** condition.

- **A** = Normal pigmentation (Dominant)
- **a** = Albinism (Recessive)

Problem 1

A man who is **homozygous dominant (AA)** has children with a woman who is **albino (aa)**.

Draw the Punnett square:

```
       __a__    __a__
     |        |        |
  A  |        |        |
     |________|________|
     |        |        |
  A  |        |        |
     |________|________|
```

What is the genotype of all offspring?

____

What is the phenotype of all offspring?

____

Could any of the offspring be albino? Why or why not?

____

Problem 2

Now suppose one of the children from Problem 1 (who is **heterozygous, Aa**) marries another person who is also **heterozygous (Aa)**.

Draw the Punnett square for Aa × Aa in the space below or on scratch paper.

What are the expected genotypic percentages?

- AA: ________ %
- Aa: ________ %
- aa: ________ %

What fraction of the offspring would you expect to be albino?

____

What fraction would be carriers (heterozygous) but appear normal?

____

Part 4: Dragon Genetics 🐉

> ***Learning Goal:*** *Apply Punnett squares to a fun, fictional organism and predict offspring traits.*

Welcome to the **Dragon Hatchery!** In this exercise, you will cross dragons and predict what their baby dragons will look like. Dragon traits follow simple Mendelian inheritance.

Dragon Trait Guide

Trait	Dominant Phenotype	Dominant Allele	Recessive Phenotype	Recessive Allele
Breath	Fire-breathing 🔥	**F**	Ice-breathing ❄️	**f**
Wing Shape	Pointed wings 🦇	**W**	Rounded wings 🪶	**w**
Scale Color	Green scales 🟢	**G**	Gold scales 🟡	**g**

Cross 1: Fire or Ice?

Mother Dragon: Heterozygous fire-breather (**Ff**)
Father Dragon: Heterozygous fire-breather (**Ff**)

Set up the Punnett square for Ff × Ff.

Out of 4 baby dragons, how many would you expect to breathe fire? ______

Out of 4 baby dragons, how many would you expect to breathe ice? ______

What is the probability (as a fraction) of a baby dragon being an ice-breather?
______

Cross 2: The Mystery Dragon

A **gold-scaled dragon (gg)** mates with a **green-scaled dragon whose genotype is unknown**.

They produce 8 baby dragons. **All 8** have green scales.

Based on this result, what is the most likely genotype of the green-scaled parent? (GG or Gg?) Explain your reasoning.

______

If the green-scaled parent had been heterozygous (Gg), what fraction of the offspring would you expect to have gold scales?
______

Cross 3: Design Your Dragon

Now it's your turn! You will design a pair of parent dragons and predict their offspring.

Choose ONE trait from the Dragon Trait Guide.

Trait chosen: ______

Mother's genotype: ______ → **Phenotype:**
______

Father's genotype: ____ → **Phenotype:** ____

Draw the Punnett square and list the predicted offspring genotypes and phenotypes below.

BONUS: Draw or describe one of the baby dragons. What does it look like? What does it breathe?

Part 5: My Traits — Dominant vs. Recessive in Humans

> ***Learning Goal:*** *Observe dominant and recessive traits in yourself and classmates.*

Many human traits are complex and influenced by multiple genes, but some behave (mostly) like simple Mendelian traits. Check yourself for each trait below.

Data Collection

Determine your **phenotype** for each trait and your **possible genotype(s)**. Remember: if you show the dominant phenotype, you could be homozygous dominant *or* heterozygous — write the genotype with an underscore (e.g., **T_**) to show the uncertainty.

My Genetic Profile

#	Trait	Dominant	Recessive	My Phenotype	My Possible Genotype(s)
1					
2					
3					
4					
5					

Analysis

1. For any trait where you show the recessive phenotype, what must your genotype be? Why can you be certain?

2. For a trait where you show the dominant phenotype, why can't you determine your exact genotype just by looking?

Part 6: Superhero Genetics 🦸 — Sex-Linked Inheritance

> ***Learning Goal:*** *Understand how genes on the X chromosome are inherited differently in males and females.*

Genes located on the **X chromosome** follow a special inheritance pattern. Males (XY) have only *one* X chromosome, so they express *whatever allele* is on it — even if it's recessive. Females (XX) have two copies, so a recessive allele can be masked by a dominant one.

The Superhero Trait

In this fictional scenario, the ability to fly is controlled by a gene on the X chromosome.

- **X^F** = Flying ability (Dominant)
- **X^f** = No flying ability (Recessive)

Since the gene is on the X chromosome, males need only **one** recessive allele to be unable to fly, while females need **two**.

Genotype	Sex	Phenotype
X^FX^F	Female	Can fly
X^FX^f	Female	Can fly (carrier)
X^fX^f	Female	Cannot fly
X^FY	Male	Can fly
X^fY	Male	Cannot fly

Problem: The Superhero Family

A **carrier mother (X^FX^f)** who can fly has children with a **father who can fly (X^FY)**.

1. Set up the Punnett square:

```
          X:F        X:f
       ___________________
X:F  |          |          |
     |__________|__________|
Y    |          |          |
     |__________|__________|
```

1. Fill in the four offspring genotypes from the Punnett square.

2. What is the probability of having a DAUGHTER who cannot fly?

3. What is the probability of having a SON who cannot fly?

4. Could any of their daughters be carriers? If so, what is the probability?

5. Explain why sons are more likely than daughters to lack the flying ability, even though both parents can fly.

6. This pattern is the same one seen in real human X-linked traits like color blindness and hemophilia. Why are these conditions much more common in males?

Conclusion

1. In your own words, explain Mendel's Law of Segregation. Why does it matter for predicting offspring traits?

2. In the Dragon Genetics exercise, what was the phenotypic ratio you predicted for Cross 1 (Ff × Ff)? How does this demonstrate a classic Mendelian pattern?

3. Compare autosomal inheritance (like dragon scale color) to sex-linked inheritance (like the flying trait). What is the key difference in how these traits are passed to sons versus daughters?

Lab created for BIOL-8: Human Biology