

Genetics in *Harry Potter's* World

Lesson 2

- Beyond Mendelian Inheritance
- Genetics of Magical Ability

Rules of Inheritance

- Some traits follow the simple rules of Mendelian inheritance of dominant and recessive genes.
- Complex traits follow different patterns of inheritance that may involve multiples genes and other factors.

For example,

- **Incomplete or blended dominance**
- **Codominance**
- **Multiple alleles**
- **Regulatory genes**

Any guesses on what these terms may mean?

Incomplete Dominance

- Incomplete dominance results in a phenotype that is a blend of a heterozygous allele pair.
Ex., **Red flower** + **Blue flower** => **Purple flower**
- If the dragons in *Harry Potter* have fire-power alleles F (strong fire) and F' (no fire) that follow incomplete dominance, what are the phenotypes for the following dragon-fire genotypes?

– FF

– FF'

– F'F'

Incomplete Dominance

- **Incomplete dominance** results in a phenotype that is a blend of the two traits in an allele pair.
Ex., **Red flower** + **Blue flower** => **Purple flower**
- If the Dragons in *Harry Potter* have fire-power alleles F (strong fire) and F' (no fire) that follow incomplete dominance, what are the phenotypes for the following dragon-fire genotypes:

<u>Genotypes</u>	<u>Phenotypes</u>
FF	strong fire
FF'	moderate fire (blended trait)
F'F'	no fire

Codominance

- **Codominance** results in a phenotype that shows both traits of an allele pair.
Ex., **Red flower** + **White flower** => **Red & White** spotted flower
- If merpeople have tail color alleles **B** (blue) and **G** (green) that follow the codominance inheritance rule, what are possible genotypes and phenotypes?

Genotypes Phenotypes

Codominance

- **Codominance** results in a phenotype that shows both traits of an allele pair.
Ex., **Red flower** + **White flower** => **Red & White** spotted flower (both traits)

- If merpeople have tail color alleles **B** (blue) and **G** (green) that follow the codominance inheritance rule, what are possible genotypes and phenotypes?

Genotypes

BB

GG

BG

Phenotypes

blue tail

green tail

blue & green tail (both traits)

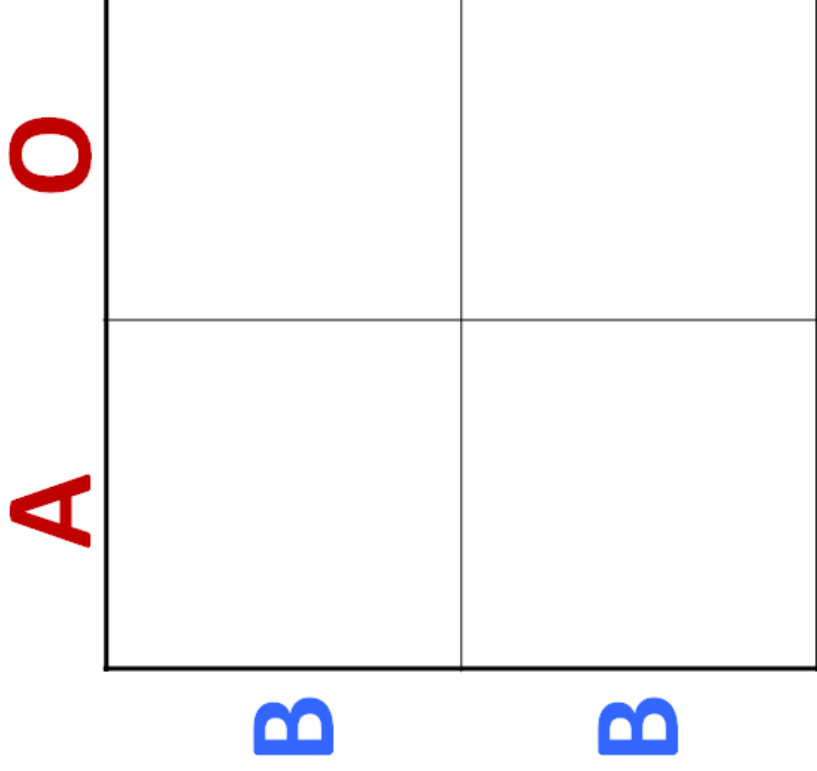
Multiple alleles

- **Multiple alleles** have more than 2 variations.
Ex., human blood type has 3 different allele variants, A, B, and O.

Genotypes	Phenotypes
AA, AO	A blood type
AB	AB blood type
BB, BO	B blood type
OO	O blood type

Multiple Alleles: Human Blood type

If parents have A (AO) and B (BB) blood types, what are the possible genotypes and phenotypes of their children?



Multiple Alleles: Human Blood type

If parents have A (AO) and B (BB) blood types, what are possible genotypes and phenotypes of their children?

A	O
B	BO
B	BO

Genotypes: AB and BO

Phenotypes: AB and B blood types

Regulatory Genes

- **Regulatory genes** regulate the expression of other genes.
- For example, a regulatory gene may 'silence' another gene from expressing its dominant trait. The Manx cat has no tail because it has a regulatory gene that silences the gene that expresses the tail. This tail silencing gene is **dominant** and has possible alleles:
 - S** = silences tail gene = no tail (Manx cat)
 - s** = doesn't silence tail gene = has tail (non-Manx cat)

Question: Can 2 Manx cats without tails have a kitten with a tail? Show your answer using Punnett Square.

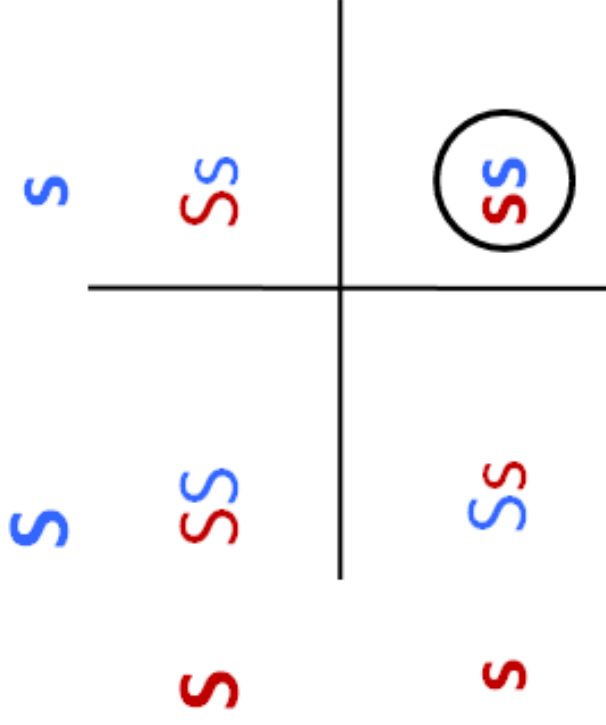
Regulatory Genes: Manx Cat

Question: Can 2 Manx cats without tails have a kitten with a tail? Show your answer using Punnett Square.

The possible alleles for the tail-scilencing gene are:

S = no tail (dominant)

s = has tail (recessive)



Only if both parent cats have the heterozygous genotype-- Ss, there is a 25% chance for their having a kitten with a tail.

Complex Traits in *Harry Potter*

- What kind of gene inheritance may be responsible for Hagrid's height which is about 12 feet?
- What is the genotype for Harry's eye color? If he had any siblings, what colors would their eyes be?

Complex Trait: Hagrid's Height

- Hagrid's father was a wizard and his mother was a giantess. The normal heights for giants and wizards are: Giants = about 20 ft. & Wizard = 5-6 ft.
- Given that Hagrid is described to be about 12 ft., what type of genetic inheritance may be at work for Hagrid's height?

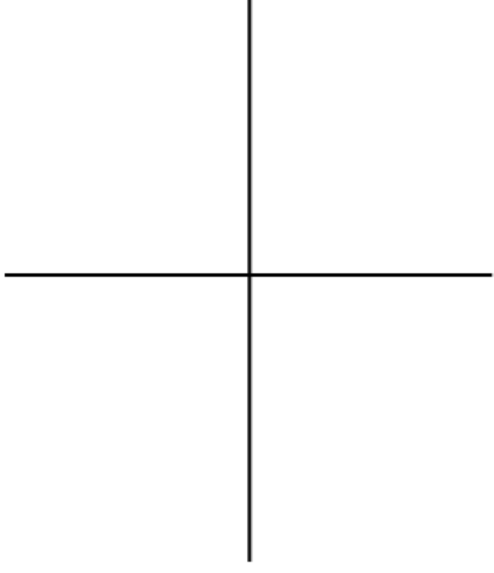
Complex Trait: Hagrid's Height

- Hagrid's father was a wizard and his mother was a giantess. The normal heights for giants and wizards are: Giants = 20-25 ft. & Wizard = 5-6 ft.
- Given that Hagrid is described to about 12 ft., what type of genetic inheritance may be at work for Hagrid's height?

Hagrid's height is close to the average of the heights of a wizard and a giantess, $(5+20)/2=12.5$ ft, which shows **incomplete dominance**.

Complex Trait: Harry's Eyes

- Eye color in humans has multiple alleles:
 - **B** = brown (codominant with green)
 - **G** = green (codominant with brown)
 - **b** = blue (recessive to both brown and green)
- Draw a Punnett Square with Harry's parents:
assuming Lily with green eyes (**GG**) and James with
hazel eyes (**BG**).



Complex Traits: Harry's Eyes

- Eye color in humans has multiple alleles:
 - **B** = brown (codominant with green)
 - **G** = green (codominant with brown)
 - **b** = blue (recessive to both brown and green)
- Draw a Punnett square with Harry's parents: Lily with green eyes (**GG**) and James with hazel eyes (**BG**).

There is a 50% chance that Lily and James would have a child with green or hazel eyes. Harry inherited the green eyes.

	G	G
B	BG	BG
G	GG	GG

Complex-Trait Activity: Magical Ability

(independent group activity)

In the *Harry Potter* series, characters are born with or without magical ability. Those with magical ability also show very strong, normal or weak ability.

Assuming that the magical ability is inherited, identify the possible phenotypes and genotypes of the following characters: Harry, Hermione, Ron, Dumbledore, Aunt Petunia, and Mr. Filch

Hints: Start by identifying phenotypes which will provide possible genotypes. Also consider whether simple Mendelian or complex traits apply to the magical ability traits.

Complex-Trait Activity: Magical Ability

(guided activity)

In the *Harry Potter* series, characters are born with or without magical ability. Those with magical ability also show very strong, normal or weak ability.

Assuming that the magical ability is a genetic trait, what are possible phenotypes and genotypes of the following characters?

Harry, Hermione, Ron, Dumbledore, Aunt Petunia, and Mr. Filch

Magical Ability: Possible Phenotypes

How would you describe the following characters' magical ability?

- Harry
- Hermione
- Ron
- Dumbledore
- Aunt Petunia
- Mr. Filch

Magical Ability: Possible Phenotypes

How would you describe the following characters' magical ability?

- Harry has strong magical ability
- Hermione has strong magical ability
- Ron has average magical ability
- Dumbledore has strong magical ability
- Aunt Petunia has no magical ability
- Mr. Filch has weak magical ability

The descriptions divide into two different categories of observable traits—1) expression and 2) strength of magical ability, which may indicate two genes responsible for the ability.

Magical Ability: Possible Phenotypes

How would you describe the following characters' magical ability?

- Harry has strong magical ability
- Hermione has strong magical ability
- Ron has average magical ability
- Dumbledore has strong magical ability
- Aunt Petunia has no magical ability
- Mr. Filch has weak magical ability

Each category of magical ability description represents a gene responsible for certain observable traits:

Expression—has the ability or doesn't have the ability

Strength—has strong, average, or weak magical ability

Magical Ability: Possible Genotypes

What are the possible genotypes that may correspond to the 2 genes (expression and strength of magical ability) below?

Gene 1: expression of magical ability

Expressed (witches & wizards)

Not expressed (Muggles do not have magical ability)

Gene 2: strength of magical ability

Strong

Average

Weak (i.e., squibs)

Hint: Are the two phenotypes complex traits and not simple Mendelian traits?
If so, what type of complex trait are they?

Magical Ability: Possible Genotypes

What are possible genotypes for the phenotypes of expressed and not expressed magical ability?

— Two Muggle parents can have a child with magical ability, like Hermione → Muggles must have a gene for magic that is not expressed or silenced by another regulatory gene.

— The possible alleles for the silencing gene are: **S (dominant)** or **s (recessive)**. The genotypes of the allele pair for expressed or not expressed phenotypes are:

Expressed (witches & wizards) —**ss**

Not expressed (Muggles) —**SS, Ss**

Magical Ability: Possible Genotypes

What are possible genotypes for the phenotypes of the strength of magical ability?

- There are three phenotypes described for the strength of magical ability: strong, average, or weak.
- Given “strong + weak=average”, the magical strength gene with **M (strong ability)** and **M' (weak ability)** alleles affected by incomplete dominance can produce the genotypes corresponding to the three different phenotypes:

Strong ability — **MM**

Average ability — **MM'** (incomplete dominance)

Weak ability (i.e., squibs) — **M'M'**

Magical Ability: Possible Genotypes

Summary of phenotypes and genotypes
for magical ability

There are two genes related to magical ability.

Possible genotypes of the two genes (two pairs of alleles) are:

Expressed (witches & wizards) —**ss**

Not expressed (muggles) —**Ss, SS** (silencing gene)

Strong —**MM**

Good/normal —**MM'** (incomplete dominance)

Weak (i.e., squibs) —**M'M'**

Magical Genes: Summary of 2 Genes

- Must be **ss** to have magical ability:
 - **MMss** = very powerful wizard
 - **MM'ss** = average wizard
 - **M'M'ss** = very weak wizard (or squib)
- If you have at least one **S** you are a Muggle:
 - **MMss**, **MM'ss**, **M'M'ss** = a Muggle who could have children with magical ability with a spouse with at least one **s**
 - **MMSS**, **MM'sS**, **M'M'SS** = a Muggle who would never have children with magical ability

Magical Ability: Characters' Genotypes

Using the genotype summary, what are possible genotypes of each character?

- Harry: strong magical ability (**MMss**)
- Hermione: average magical ability (**MMss**)
- Ron: average magical ability (**MM'ss**)
- Dumbledore: strong magical ability (**MMss**)
- Aunt Petunia: no magical ability (**MMSS, MM'Ss, M'M'Ss, MM'SS, M'M'SS**)
- Mr. Filch: weak magical ability (**M'M'ss**)

Magic Runs in Families

Answer the following questions and provide reasoning for your answers:

- Hermione’s possible genotype is **MMss**, indicating her strong magical ability. What are possible genotypes of Hermione’s parents who are Muggles without the ability?
- Harry Potter married Ginny Weasley. Will all of their children have magical ability?
- Could Dudley Dursley potentially have children with magical ability?

Hermione's Parents

Question: What are possible genotypes of Hermione's parents who are Muggles (no magical ability)?

- Hermione's genotype is **MMss**.
 - For Hermione's inherited **ss**, both of her Muggle parents must have **Ss**.
 - For Hermione's inherited **MM**, both parents may have **MM** or **MM'**, but neither parents can have **M'M'** allele pair.
- Hermione's parents' possible genotypes are:
 - **MMss**, or **MM'Ss**

Harry and Ginny's Children

Question: Will all of Harry and Ginny's children have magical ability?

- Parents' magical genes:
 - Harry's genotype is **MMss**.
 - Ginny's genotype may be **MMss** or **MM'ss**.
- Harry's and Ginny's children's genotypes:
 - Since Harry and Ginny each has an **ss** allele pair, they can only pass **s** alleles to their children. Therefore, all of their children having inherited **ss** allele pair, have magical ability.

Dudley's Children

Question: Could Dudley Dursley potentially have children with magical ability?

- Dudley's parents' genotypes:
 - **Vernon Dursley** is about as magic-less as one can get. So let's assume Vernon's genotype is **M'M'SS**.
 - **Petunia's** sister Lily Potter had magical ability. So, Petunia can have a genotype of **SS** or **Ss** allele pair.
- Dudley's genotypes:
 - If Dudley inherited **S** allele from both parents, he cannot have kids with magical ability.
 - If Dudley inherited an **s** allele from Petunia, he can have kids with magical ability with a Muggle with an **Ss** allele pair, or a witch possessing an **ss** allele pair.