MENDELIAN GENETICS PART II

Co-Dominance, Incomplete Dominance, and Epistasis

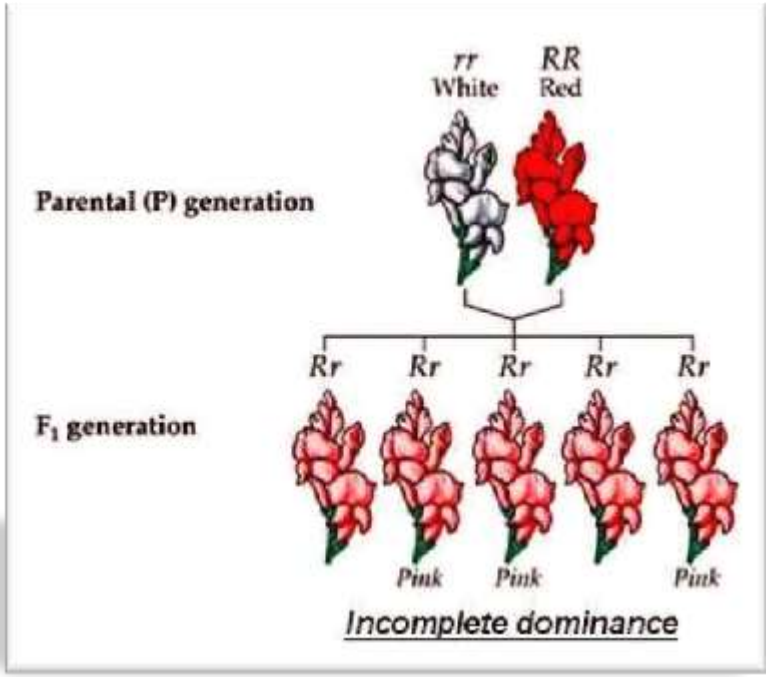
Review

- Basic Mendelian Genetics –
  - Some genes are dominant and are always expressed
  - Some genes are recessive and only expressed if no dominant genes are present
  - Every individual has at least 2 alleles (versions) of every gene
  - Parents each contribute an equal number of alleles to their offspring
  - The allele they contribute is a result of random chance.

- Lets “Kick it up a notch”
- Genes aren’t always exclusively recessive or dominant.
- Sometimes they are a mixture of one or the other or both.
- Sometimes a gene requires a different gene to be expressed or silenced in order for it to be expressed.

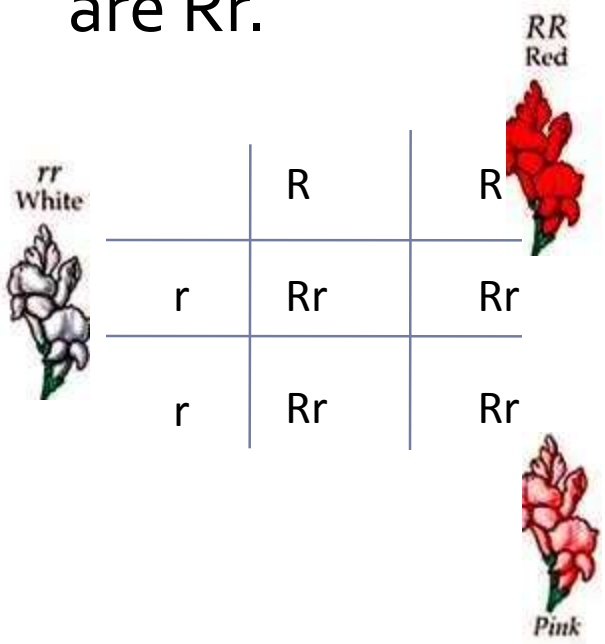
Incomplete Dominance

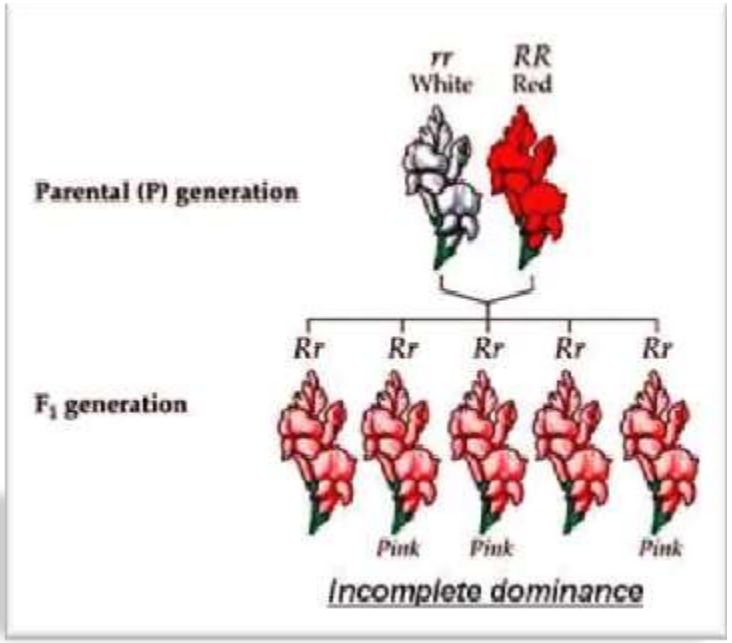
- Incomplete dominance occurs when neither allele is dominant.
- For example, if flower is red and the other flower is white, they may have offspring that have a mix of both of their traits – pink.
- If red and white parents have pink offspring, the gene for color would be incompletely dominant.
- Incomplete dominance = *A mix of Dominant and Recessive*



Incomplete Dominance & Punnett Squares

- In Incomplete Dominance, nothing changes with the Punnett Square (except that we now have 3 phenotypes instead of 2)
- In this case, White is rr, Red is RR, and the pink heterozygous offspring are Rr.





Incomplete Dominance

- When traits are inherited incompletely, or they mix.

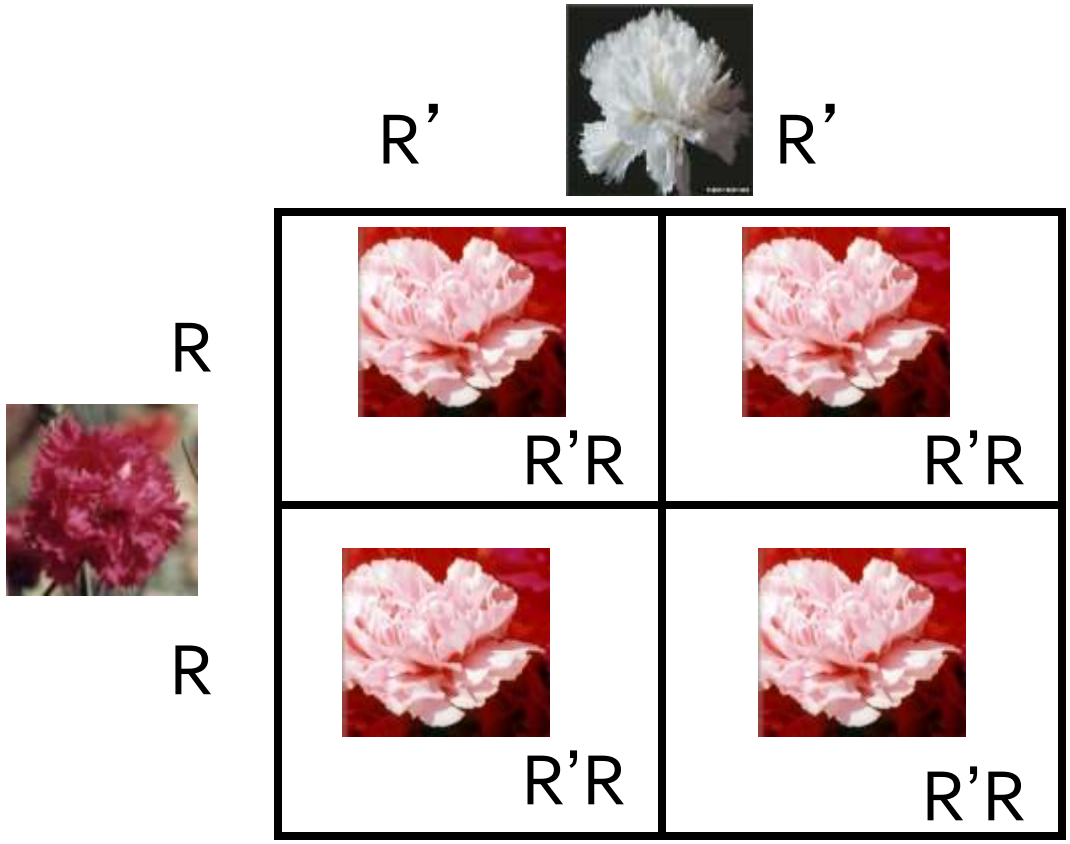
Red Carnations

Genotype (RR)

White Carnations

Genotype (R'R')

Incomplete Dominance



Incomplete Dominance

	R’ 	R
R’ 	 R’R’	 R’R
R	 R’R	 RR

Co-Dominance

- Co-Dominance is a little more tricky.
- In Co-Dominance, multiple traits can be dominant.
- For example, in livestock and horses, a unique color called "Roan" exists.
- Roan looks pink, but it is NOT pink – Roan is a blend of red and white hair.

Roan – Red AND White

- A close-up of a roan animal's coat shows that the hair is not pink – it is BOTH red and white.

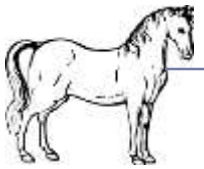
Roan & Co-Dominance

- Roan occurs because in some cattle and horses, both red and white hair are dominant.
- The sire (father) is on the left and is white
- The mother is on the right and is dun (reddish brown). The colt is Dun Roan – a blend of white and dun hairs.

Co-Dominance and Punnett Squares

- Co-Dominance is a little more tricky in Punnett Squares.
- Because both traits are dominant, both need to be capitalized.
- Because both need to be capitalized, we need two different letters to show co-dominance.

	R	R
W	RW	RW
W	RW	RW



Co-Dominance & Blood Type

A + B = A, B, AB, or O

Co-Dominance & Blood Type

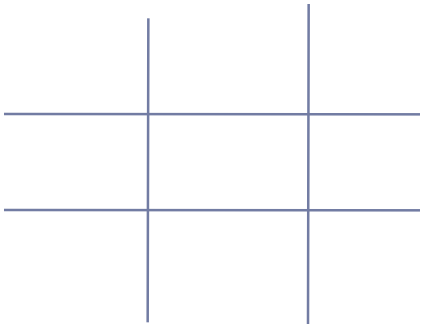
- Co-dominance plays a very distinct role in blood type.
- Both Type A and Type B blood are dominant.
- Type O blood is recessive.
- If your father contributes the gene for Type A and your mother the gene for Type B, you will be Type AB, or co-dominant for blood type.

Blood Type & Punnett Squares

- In a Punnett Square, we write out blood type as either I^A , I^B , or i (for the recessive O type).
- If you had both I^A and i (O) blood types, only the A allele would be expressed and you would have Type A blood.
  - The same is true for Type B blood.
- The only way to have Type O blood is if you received both recessive alleles – i and i

Blood Type & Punnett Squares

- In a Punnett Square, you might see the following:
- Suppose one parent is heterozygous for Type A and O blood; the other parent is heterozygous for Type B and O blood.



Why Blood Type Matters

- This matters because your blood type is sort of like the team you cheer for.
- Blood Type represents the protein coating of your blood. If you have Type A, your body in instructed to kill off Type B and vice versa.
  - If you were Type A and given Type B, there would be blood cell gang-warfare in your body.
  - Type A cannot receive any Type B and vice versa.

Type O and Type AB Donors

- Type O is the universal donor-
  - Anyone can receive Type O blood without a problem
  - Type O people can only receive Type O blood
- Type AB is the universal recipient –
  - Because they have both A and B, they can receive either A or B (or O or AB) without any problems
  - They can only give to other AB Type people though.

Codominance

- The expression of both alleles
- Neither one of the alleles are dominant or recessive, and is expressed in the offspring.
- Ex. - In some chickens, alleles for feather color are codominant.

Codominance

- Alleles are written with superscripts.

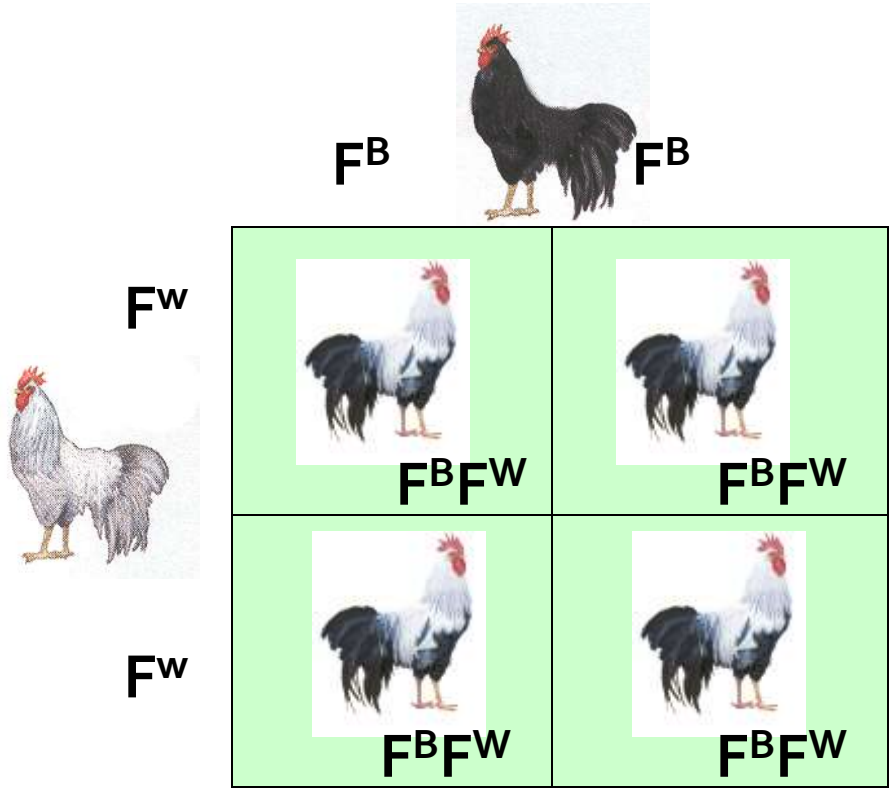
Genotype = $F^B F^B$

Phenotype = Black

Genotype = $F^w F^w$

Phenotype = White

Codominance



Codominance

- Other example of Codominance.

Epistasis

White + White = White, Yellow, or Green

Epistasis

- Your genes do not operate in isolation from each other.
- The expression of one gene can affect the expression of another gene.
  - E.g. men have the genes for mammary production but obviously do not express them because of other male genes
- **Epistasis** - the interaction between two or more genes to control a single phenotype

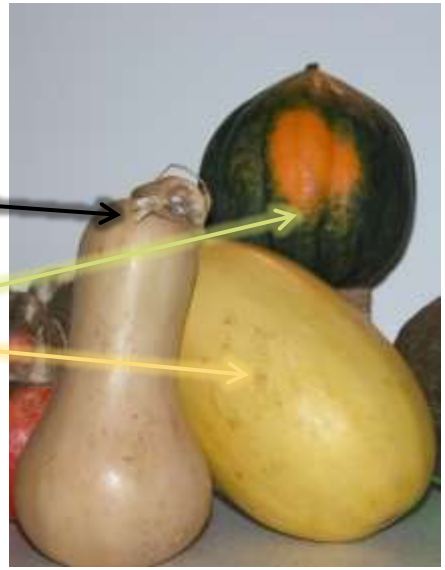
Epistasis & Squash

- Epistasis is easily visible in squash.
- In squash, two genes work together to determine color.
- The “W” gene determines if the squash is white or colored (white is dominant)
- The “G” gene determines if the squash is yellow or green (yellow is dominant)
- To determine the color or lack thereof, we have to look at both genes.

Squash & Epistasis

- WW or Ww – the squash is colorless (white)
- ww – the squash has color
- GG or Gg – the squash, if colored, is yellow
- gg – the squash, if colored, is green.

- White = W_G_ or W_g_
- Yellow = wwG_
- Green = wwgg



Squash & Epistasis Problem

- Imagine we have a double-heterozygous squash (WwGg)
  - This would be a white squash
- We cross-pollinate our double-heterozygous squash with another of the same genotype.
  - WwGg x WwGg
- What would their offspring look like?

Larger Punnett Squares

- To solve this problem, we would need to create a 16-square Punnett Square

	WG	Wg	wG	wg
WG	WWGG	WWGg	WwGG	WwGg
Wg	WWGg	WWgg	WwGg	Wwgg
wG	WwGG	WwGg	wwGG	wwGg
wg	WwGg	Wwgg	wwGg	wwgg

Larger Punnett Squares

- To create this kind of Punnett Square, begin by adding the parents to the top and side.
- WwGg becomes – 1) WG; 2) Wg; 3) wG; 4) wg
- Each allele has to be paired with all other alleles.

WwGg / WwGg	WG	Wg	wG	wg
WG				
Wg				
wG				
wg				

Larger Punnett Squares

- Next, fill in each row by pairing the W's and the G's to make the offspring's genotype.
  - Capital letters (dominant traits) are always listed first.

	WG	Wg	wG	wg
WG	WWGG	WWGg	WwGG	WwGg
Wg	WWGg	WWgg	WwGg	Wwgg
wG	WwGG	WwGg	wwGG	wwGg
wg	WwGg	Wwgg	wwGg	wwgg

Larger Punnett Squares

- Finally, determine your offspring's phenotypes.

	WG	Wg	wG	wg
WG	WWGG	WWGg	WwGG	WwGg
Wg	WWGg	WWgg	WwGg	Wwgg
wG	WwGG	WwGg	wwGG	wwGg
wg	WwGg	Wwgg	wwGg	wwgg

Larger Punnett Squares

- In this case, we'd see the following (again, colorless is dominant; any W's mean no color)
- 12 white; 3 yellow; 1 green (always make sure you add up to 16)

	WG	Wg	wG	wg
WG	WWGG	WWGg	WwGG	WwGg
Wg	WWGg	WWgg	WwGg	Wwgg
wG	WwGG	WwGg	wwGG	wwGg
wg	WwGg	Wwgg	wwGg	wwgg

Conclusion

- Incomplete Dominance – when two traits blend to create a new trait (e.g. Red + White = Pink)
- Co-Dominance – when two traits are both dominant (e.g. Type AB blood)
- Epistasis – when one gene affects the expression of another gene.

Dihybred Cross

- Round seeds are dominant R
- Wrinkled seeds are recessive r
- Yellow seeds are dominant Y
- Green seeds are recessive y

Dihybred Cross

- Female
  - YyRr
- Male
  - YyRr

	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Dihybred Cross

- Phenotype
- Ratio
  - 9:3:3:1
- Genotype