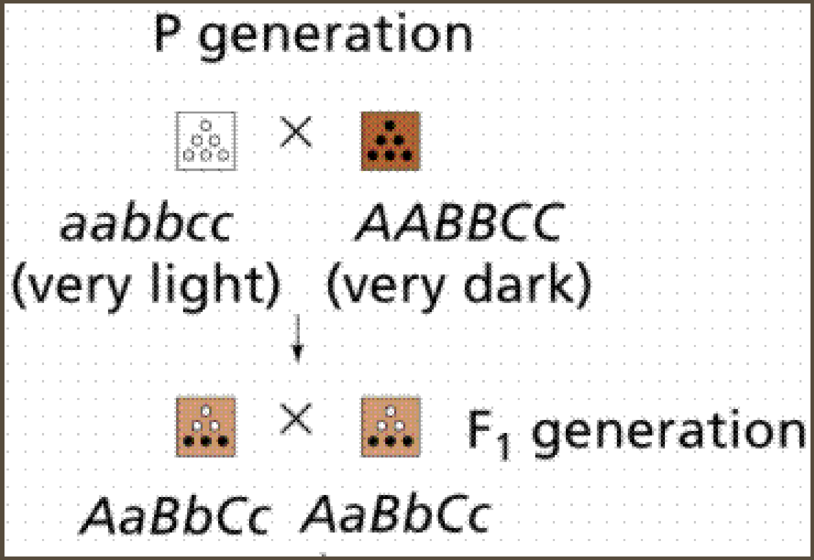
ADVANCED GENETICS

POLYGENES

- For some traits, an individual may have four, six, or more genes.
  - When a group of genes work together to influence a single trait, this is known as a polygene.
- For example, human skin color is a polygenic trait (or a trait controlled by multiple genes).
  - Six alleles determine the pigment of your skin.
  - The more dominant genes you have for
  - skin color, the darker your skin will be.
- For example, imagine that a very dark-skinned person had a child with a very light-skinned person.



PLEIOTROPY

Sometimes a single gene can affect more than one trait.

- When one gene influences multiple unrelated traits, this is known as pleiotropy (PLY-oh-TROH-pee).

For example, chickens can inherit a "frizzle" gene that causes them to produce fuzzy, poofy feathers.

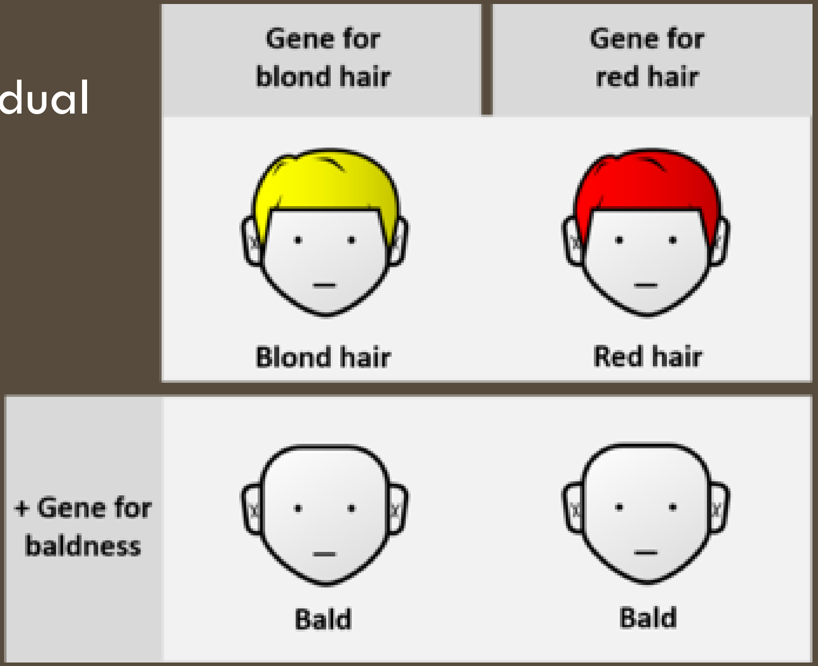
- This may look funny but can be advantageous for chickens in warm climates to help keep them cool.
- However, the frizzle trait also causes these chickens to lay fewer eggs and have a reduced metabolic rate

A common example of human pleitropy is sickle cell anemia.

- Sickle cell anemia is a mutation in the shape of blood cells.
- Those heterozygous for sickle cell anemia also have greater resistance to malaria.

EPISTASIS

- Sometimes one gene can prevent the expression of another gene.
  - For example, male animals carry the genes for female body parts.
  - However, because they have a Y chromosome, the genes for the female parts are not expressed.
- The process in which the expression of one gene is blocked by the expression of another gene is called <u>epistasis</u>.
  - Epistasis can prevent an organism from exhibiting a trait even though that individual has the genes for that trait.
- For example →



EPISTASIS AND LABRADORS

Labrador dogs are a well-known example of a polygene and of epistasis.

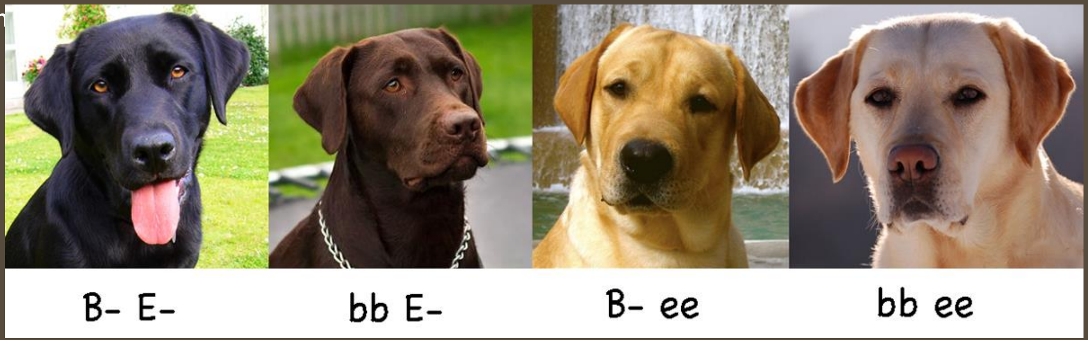
- Labradors have two genes that influence the color of their coat.
  - The E gene determines the presence of a dark pigment in their coat.
  - The B gene determines the amount of that pigment that is expressed.

For example, a Labrador puppy with genotype BBEE or BBEe would be a black lab.

- A Labrador puppy with genotype bbEE or bbEe would be a chocolate lab.

However, a Labrador puppy with genotype Bbee, BBee, or bbee would be a yellow lab.

- This is because the E gene has an epistatic effect on the B gene.
- If the puppy has both recessive "e" genes, it does not matter what combination of "B" gene is present – the dog will be a yellow lab.
  - However, oth



POLYGENES, EPISTASIS, AND PUNNETT SQUARES

- Because polygenic traits involve multiple alleles, a standard Punnett square (with 4 squares) is not enough to predict what the offspring will look like.
  - When epistasis or polygenes are involved, we need to use larger Punnett squares to determine how the combination of multiple genes will affect the phenotype of that organism.
- For example, the color of squash is determined by two different genes.
  - The “W” gene determines if the squash is white or colored.
  - The “G” gene determines if the squash is yellow or green (if it is colored).
- A Ww_ _ or WW_ _ squash will always be white.
  - A wwGg or wwGG squash is yellow.
  - A wwgg squash is green.

LARGER PUNNETT SQUARES

Imagine we cross-pollinate a double-heterozygous squash with another of the same genotype.

- In other words, we pollinate a WwGg squash with another WwGg squash. What would their offspring look like?

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

SETTING UP THE DIHYBRID PUNNETT SQUARE

To set up the dihybrid Punnett square, we first have to break down each parent's genotype into all the possible combinations that parent could give to their offspring.

- When we are using a dihybrid Punnett square, we are looking at two different genes, each with two different alleles.
- Because each parent contributes one allele from each gene, there are four possible combinations of alleles that each parent could pass onto their offspring.

For example, each squash parent had the genotype WwGg.

- Each squash could give their offspring either the W or the w allele.
- Each squash could also give their offspring either the G or the g allele.

This means that four possible combinations of these two genes could be passed on: WG, Wg, wG, or wg.

- These are the letters that will go along the top and sides of the dihybrid Punnett square.

FOIL THE GENOTYPE

An easy way to remember how to set this up is to remember the acronym "FOIL", or First Letters, Outside Letters, Inside Letters, Last Letters.

- Again, our squash genotype of WwGg.
- The FIRST letters are WG.
- The OUTSIDE letters are Wg.
- The INSIDE letters are wG.
- The LAST letters are wg.

	WG	Wg	wG	wg
WG				
Wg				
wG				
wg				

MATCH UP THE COMBO'S

Once we've set up the side and top of the dihybrid Punnett square, we simply need to match up each combination of letters to create the possible genotypes that could be created by this combination of parents.

- Remember to keep similar letters together and to write capital letters 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

DETERMINE THE OFFSPRING

Finally, use the predicted genotypes to determine what kind of offspring will be created by this cross.

- In this case, we'd see the following (again, colorless is dominant; any uppercase W's mean 'no color' or white)
- Based on the Punnett square below, we'd 12 white; 3 yellow; 1 green from this cross (always make sure your totals 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