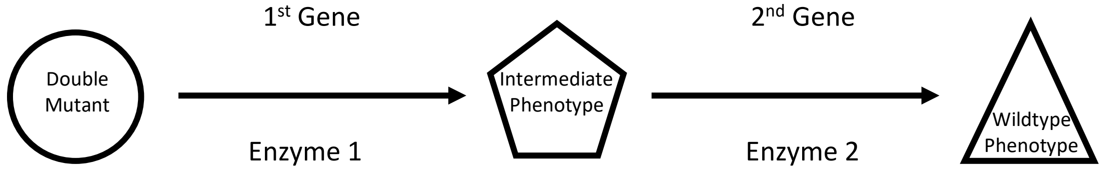
Epistasis:

Epistasis is a type of gene interaction where two genes are involved in a pathway. Each gene codes for a separate enzyme that is involved in only one step of the pathway.

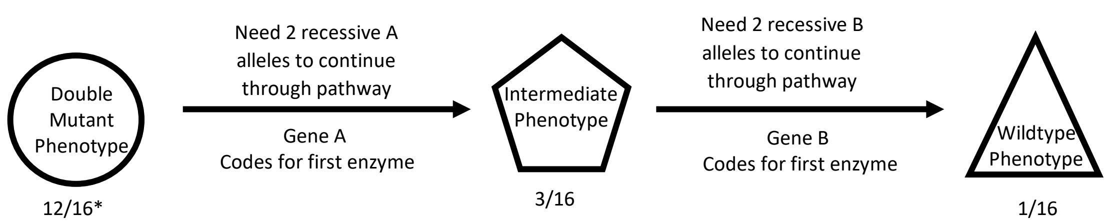
There are three phenotypic classes in an epistasis pathway. The first phenotypic class is called the double mutant. This is the phenotypic class that an individual gets stuck in if they cannot make the first enzyme regardless of the rest of their genotype. The second phenotypic class is called the intermediate. This is where an individual gets stuck if they make the first enzyme but cannot make the second enzyme. The final phenotypic class is the wildtype phenotype. An individual only has this phenotype if they can make both enzymes.



When working through dominant and recessive epistasis, notice the collapsed phenotypic classes compared to a dihybrid cross. The parents are the same, but rather than four distinct phenotypic classes as un-interacting genes have, epistasis only has three.

Dominant Epistasis:

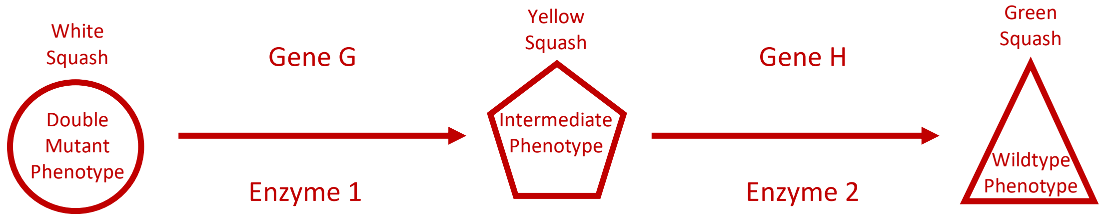
Dominant epistasis is a type of epistasis. In dominant epistasis, the mutant allele is dominant and the wildtype allele is recessive. This means that to produce a functional enzyme, an individual needs two recessive wildtype alleles for the gene. This is true of both enzymes. One way to remember the difference between dominant and recessive epistasis is with the phrase "dominant to stay". In dominant epistasis, even one dominant (mutant) allele for a gene will result in not making the enzyme that gene codes for and not proceeding forward through the pathway. This is how an individual can get "stuck" in a phenotypic class.



Practice:

G and H are the first and second gene in a dominant epistasis pathway involved in squash color. Answer the following questions to practice your knowledge of dominant epistasis.

1. Draw a picture of this pathway and label the double mutant, intermediate phenotypic class, and the wildtype phenotypic class. Then, label the first and second enzyme in the pathway and what gene G and gene H represent. (You can add further information to this figure as you work through the following problems).



2. A farmer has a plot with yellow, green, and white squash. He notices that most his squash are white colored. He has nearly twelve times as many white squash as he does green squash. Identify the following:

   a. The double mutant phenotype: White

   b. The intermediate phenotype: Yellow

   c. The wildtype phenotype: Green

3. This farmer comes to you, the geneticist, for help. He wants to grow at least 290 yellow squash for the local farmer's market this year. If he only bought 1240 seeds from certified heterozygous squash plants for this year, do you expect that he can grow enough yellow squash for the market? Why or why not?

   No, yellow phenotype will occur in about 3/16 of the seeds. He will likely have only around 233 yellow squash from this amount of seeds.

   Note: ratios are a likelihood, not an exact amount of offspring from a cross. Because each seed's genetic material does not affect the next seed, it is possible that more of one phenotype of squash could be produced. However, it is highly unlikely that the squash grown will deviate very far from the known dominant epistasis ratio.

4. The farmer wants to have a plot with just one color of squash that grows year after year. He will manually pollinate these squash plants with only squash in the same plot. He does not want to have to remove any squash plants to make this possible. Would you recommend he try to get a white squash only, green squash only, or yellow squash only field? How would he do this? Explain your reasoning.

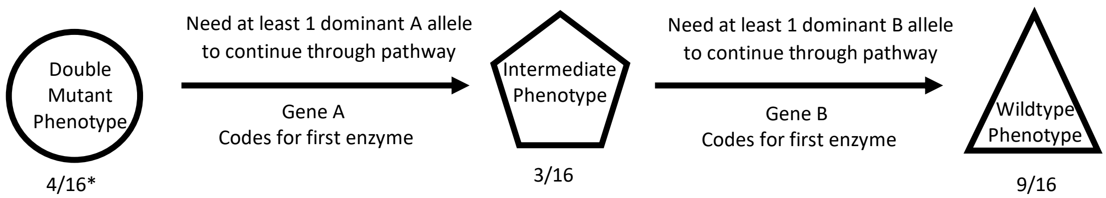
   White squash are any squash with at least one dominant allele for gene G, the first gene in the pathway. This means that it is possible white squash, when crossed, can produce green, yellow, or more white squash as offspring.
   (GgHh x GgHh cross can result in offspring that fall into each of the three phenotypic classes.)

   Yellow squash are any squash with two recessive alleles for gene G and at least one dominant allele for gene H. A cross of two yellow squash could result in yellow squash or white squash as offspring.
   (ggHh x ggHh cross can result in offspring with the genotype of ggHh, ggHH, or gghh.)

   A green squash must be homozygous recessive because it progressed through both steps of the pathway. A green squash is a true breeder and thus all of its offspring will have the genotype gghh and will have a green phenotype.
   (gghh x gghh cross can only result in offspring with the genotype of gghh.)

Recessive Epistasis:

Recessive epistasis is a type of epistasis. In recessive epistasis, the mutant allele is recessive and the wildtype allele is dominant. This means that to produce a functional enzyme, an individual needs at least one dominant wildtype allele for the gene. This is true of both enzymes. One way to remember the difference between dominant and recessive epistasis is with the phrase “recessive to stay”. In recessive epistasis, only two recessive (mutant) alleles for a gene will result in not making the enzyme that gene codes for and not proceeding forward through the pathway. This is how an individual can get “stuck” in a phenotypic class.



Practice:

Gene P codes for the first enzyme in an epistasis pathway and gene C codes for the second. Fur color in rodents is controlled by recessive epistasis. First, an enzyme allows for making of pigment which appears brown, then another enzyme changes this pigment into another colored protein that makes fur look red. Answer the following questions to practice your knowledge of dominant epistasis.

1. What are the possible genotypes of individuals with white fur (no colored pigment), brown fur, and red fur?
   White fur: ppCC, ppCc, and ppcc
   Brown fur: Ppcc and PPcc
   Red fur: PpCc, PpCC, PPCc, and PPCC
2. Your friend is studying rodent evolution. She wants to sample the DNA from a rodent who looks as similar to prehistoric rodents in their genetic material. If you are to assume DNA is relatively stable, which fur color of rodent do you think she should sample? Why?
   Mutant alleles are alleles that arose from a change in DNA. Rodents with mutations have more differences in genetic material compared to their prehistoric ancestors than wildtype rodents do. The red fur rodents are the only rodents in this example who have at least one wildtype allele for both genes.
3. If you are seeing a 9:3:4 ratio of fur color in a litter of rodents, what are the genotypes of the parent rodents? What color fur do they have?
   The ratio is based on dihybrid crosses. PpCc x PpCc is the cross. These are both red fur rodents.

Summary & Mixed Practice:

You cross many heterozygous parrots together. A log all the hatched parrots from last season is displayed below.

Phenotype	Number of parrots counted
Short Brown Tail Feathers	59
Long Brown Tail Feathers	47
Long Colorful Tail Feathers	137
	Total: 243

1. Are tail feathers controlled by dominant or recessive epistasis? Why?
   This is recessive epistasis. Recessive epistasis has a 9:3:4 ratio where 9/16 individuals have a wildtype phenotype, 3/16 individuals express the intermediate phenotype, and 4/16 individuals have the double mutant phenotype. The results here closely match this expected ratio. For instance, there were 59/243 parrots with short brown tail feathers which is almost 4/16 of the total birds.
   *Note: When asked to identify a type of gene interaction in a long answer, you should state the gene interaction, the expected offspring ratio, and then compare the given data to the expected ratio. *
2. What do the heterozygous parrot's tail feathers look like?
   A heterozygous individual will have one dominant wildtype allele for each gene and thus will make it all the way through the pathway to express the wildtype phenotype in recessive epistasis. In this example, heterozygous individuals will have long colorful tail feathers.
3. Draw a picture of the gene interaction for tail feathers. Be sure to include phenotypes, genes, genotypes, ratios, and state which alleles are mutant alleles.