

Non-Mendelian inheritance	Linkage	How to plot a gene map
1) Multiple alleles: more than two phenotypes due to more than two alleles being present	Genes are physically linked when they are on the same chromosome.	1. the lowest frequency is the double crossover
2) Incomplete dominance: both phenotypes may be dominant, resulting in an intermediate phenotype.	Genes on separate chromosomes are never linked	2. the highest is the parental genes
3) Codominance: both dominant traits are present in offspring, resulting in both alleles being expressed together.	Genes that are farther away from each other are more likely to be separated during a process called homologous recombination, and are practically unlinked	3. find the pairs of the other crossing over
3) Codominance: both dominant traits are present in offspring, resulting in both alleles being expressed together.		4. to determine the gene in the middle, look at the frequency between the parental gene and the double crossover
4) Pleiotropy: mutations have more than one phenotypic effect.		5. to calculate the distance between alleles, use the recombination frequency between one crossover and the frequency of another cross. This is calculated as the recombination frequency of both alleles in the pair, and divided by 2
5) Epistasis: interaction of more than one gene masks the phenotypic effect of one of them.		
Sex linkage	Breaking linkage	Linkage group
This is because the recessive allele on the X chromosome will show in the phenotype in males, as they have XY, so there is no dominant allele to override it (whereas females have XX, so will always have the dominant allele).	Two parental chromosomes, two recombinant chromosomes	Linkage can only be detected when recombination is less than 50%
X chromosomes – 1,000 to 2,000 genes Y chromosomes – 70 genes	Crossing over always occurs and is regulated	When genes are far apart on the chromosome, crossing over occurs, so genes appear unlinked.
Males and females carry a different dose of X, so males have dosage compensation – they produce double the amount of gene product (upregulation of X in males)	The probability of crossing over between two genes depends on their distance from each other on the chromosome.	There is a difference between 'physically linked' and 'genetically linked' – if asked how many linkage groups the chromosomes, you cannot tell.
	Double crossing over undoes the effect of one crossing over, therefore, the parental and recombinant genes stay the same.	Genetic mapping can only establish linkage between genes
	Double crossing overs close to each other are rare, due to crossing over interference: one crossing over reduces the possibility of a second.	
	Genetic mapping	
	The percentage of recombinant offspring (recombination frequency) = distance between genes on a chromosome	
	1% frequency = 1 map unit (centimorgan, cM)	

