AG2PI
Agricultural Genome to Phenome Initiative

Alleles, Inheritance, Linkage

An allele is a form of a gene; geneticists often use mutant alleles to tell us a gene's function.

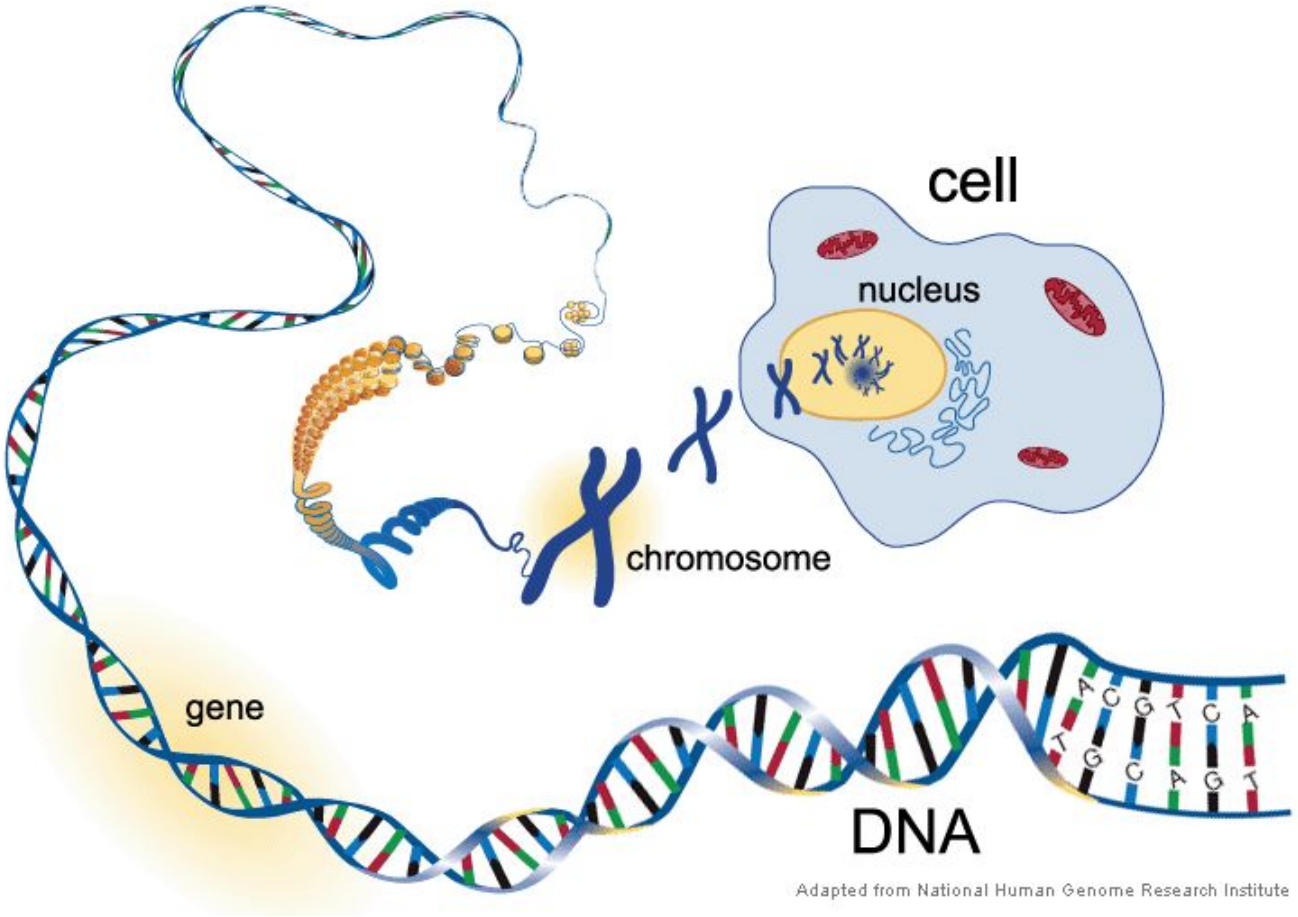
In organisms with two copies of every chromosome (diploids), chromosomes segregate from one another at meiosis so that only one allele of each gene ends up in each sperm or egg.

Landmarks on DNA located near one another on the same chromosome are likely to be inherited together ("linked"). Landmarks on DNA located on different chromosomes are inherited independently of one another ("unlinked").

Recall...

A gene is a sequence of DNA or RNA that encodes a product

Genes occur on chromosomes (long strands of DNA packaged up with protein)

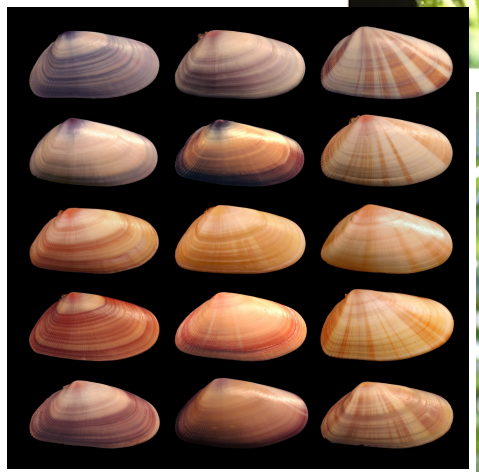


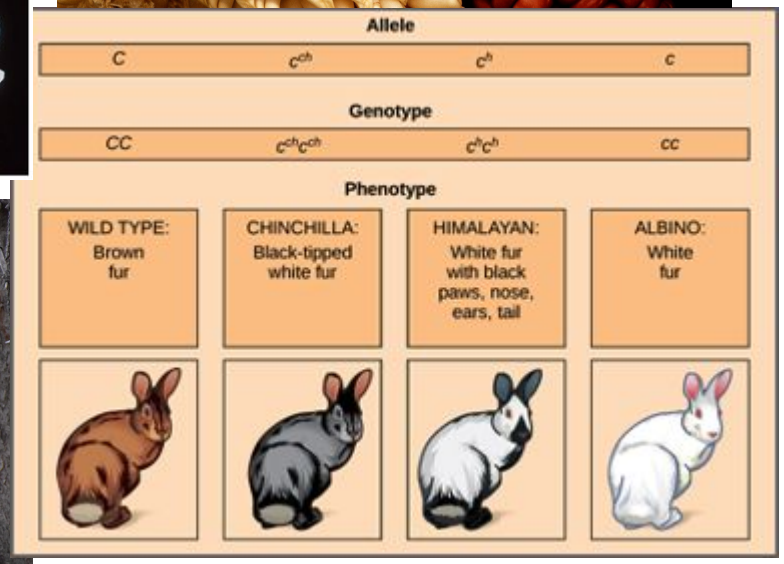
An “allele” is just a form of a gene

Any difference at all (usually a DNA sequence change) between two versions of a gene makes them two different alleles. There can be many different alleles of a gene.

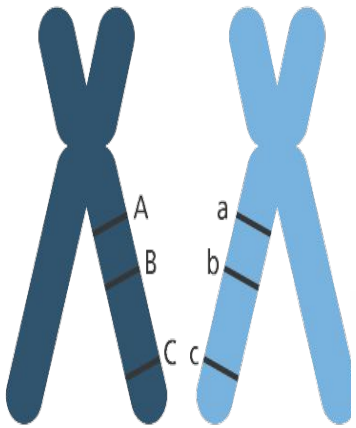
Geneticists often use **mutant** alleles to tell us a gene’s function.

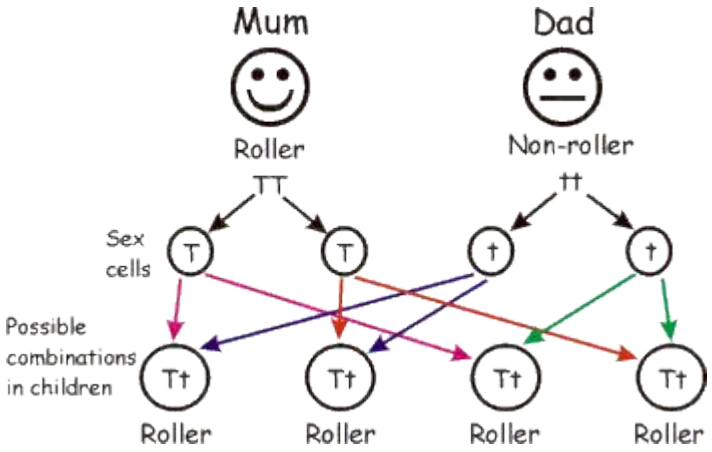
EXAMPLE: If a flower is typically purple and a mutation turns the flower white, then it is reasonable to conclude that the mutated gene normally has some role in flower color

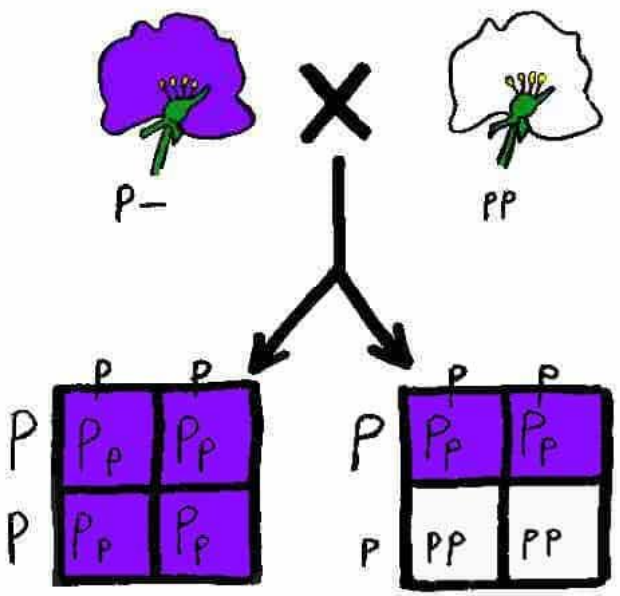




Inheritance







We often follow traits through several generations of parents and offspring to understand whether those traits are controlled by alleles of genes (heritable)

When information is passed from parent to offspring, if sex is involved then there is mixing of information from the two parents in forming the offspring

Comparing parents to offspring turns out to allow testable hypotheses about how the information is inherited (“genetics”)

Inheritance and Genetic Segregation

In organisms that have two copies of each chromosome (like you) two different alleles of the same gene can be present at the same time, one on each chromosome.

Gametes (sperm and egg) each carry only one of the copies of each chromosome--the allele are said to segregate from one another

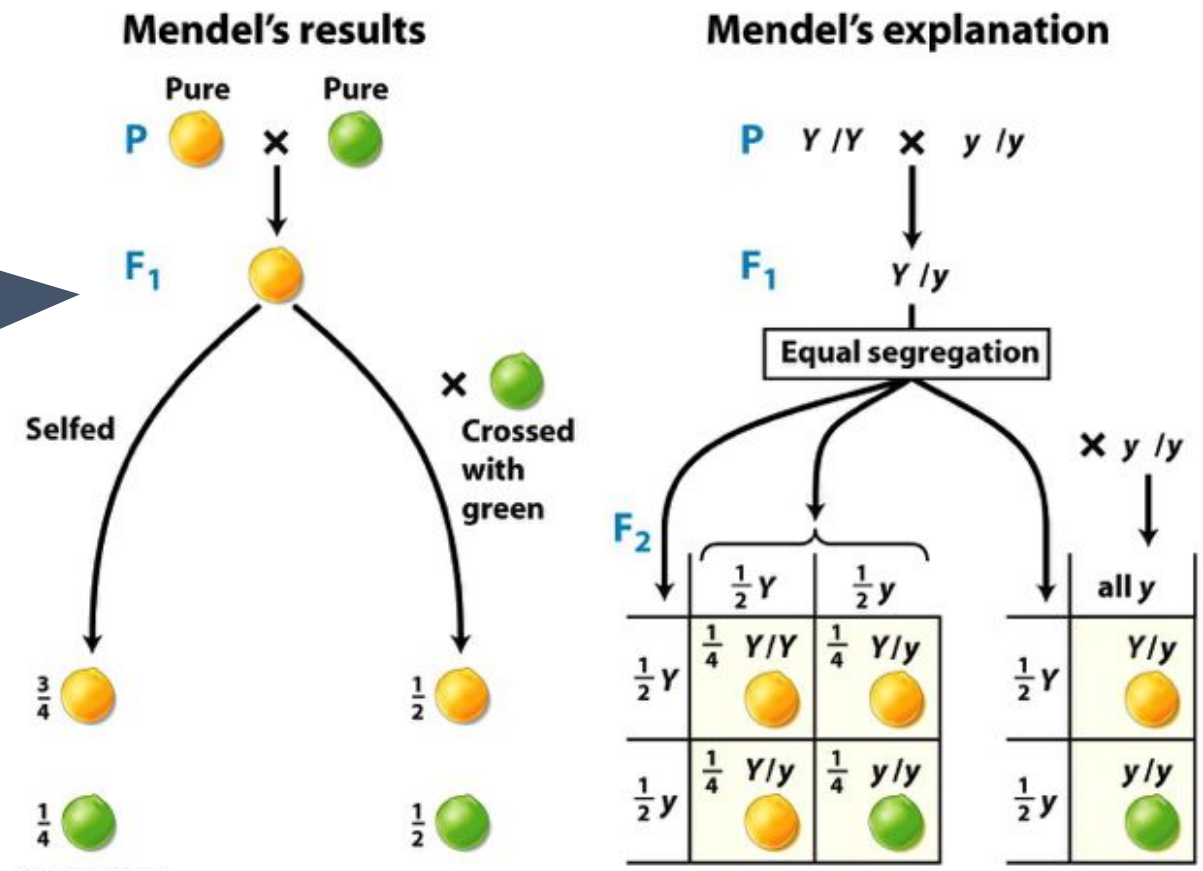
Gregor Mendel figured this out crossing plants together, counting offspring and making models and statistical predictions

DOMINANT: An allele that phenotypically masks another allele's effect

recessive: An allele that is phenotypically masked by another allele

YY= Yellow **Yy**= Yellow **yy**= Green

Mendel carefully picked only traits with two, discreet states and that all showed this general behavior and tested them

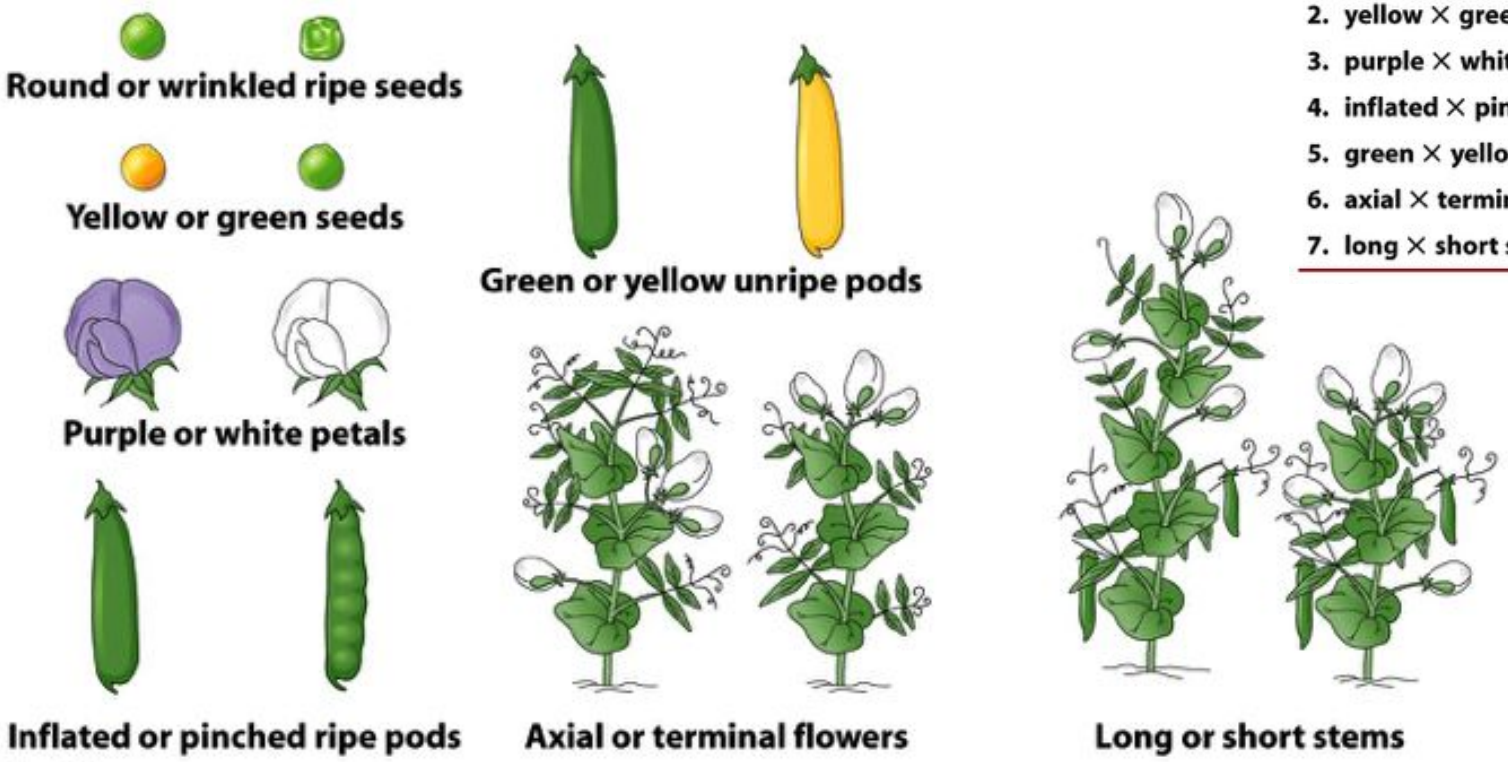


Mendel's Results

Mendel focused on <u>seven</u> different traits in peas (and others in other plants) that all acted like this. He got similar results out of all of them (probably with a little bias in scoring, but still…)

Table 2-1 Results of All Mendel's Crosses in Which Parents Differed in One Character

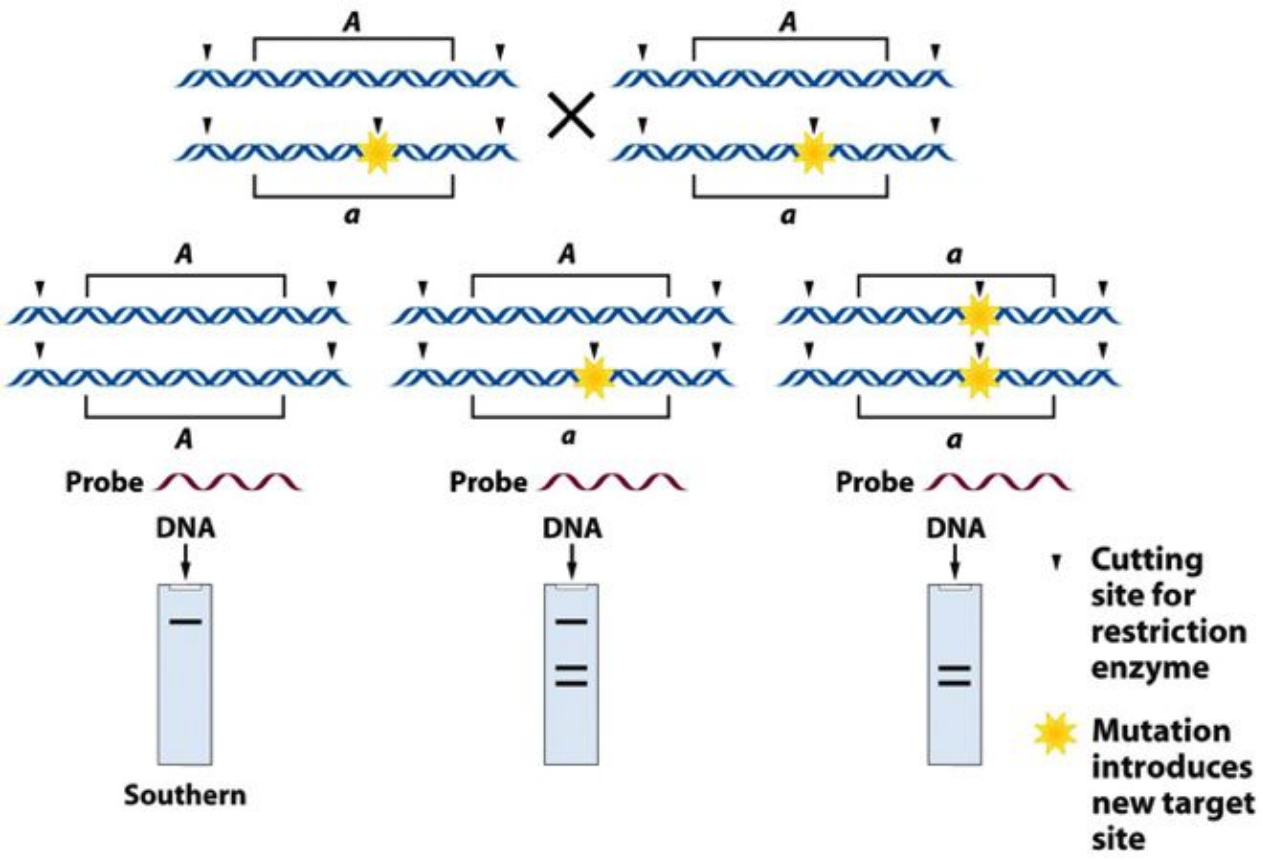
Parental phenotype	F_1	F_2	F_2 ratio
1. round × wrinkled seeds	All round	5474 round; 1850 wrinkled	2.96:1
2. yellow × green seeds	All yellow	6022 yellow; 2001 green	3.01:1
3. purple × white petals	All purple	705 purple; 224 white	3.15:1
4. inflated × pinched pods	All inflated	882 inflated; 299 pinched	2.95:1
5. green × yellow pods	All green	428 green; 152 yellow	2.82:1
6. axial × terminal flowers	All axial	651 axial; 207 terminal	3.14:1
7. long × short stems	All long	787 long; 277 short	2.84:1

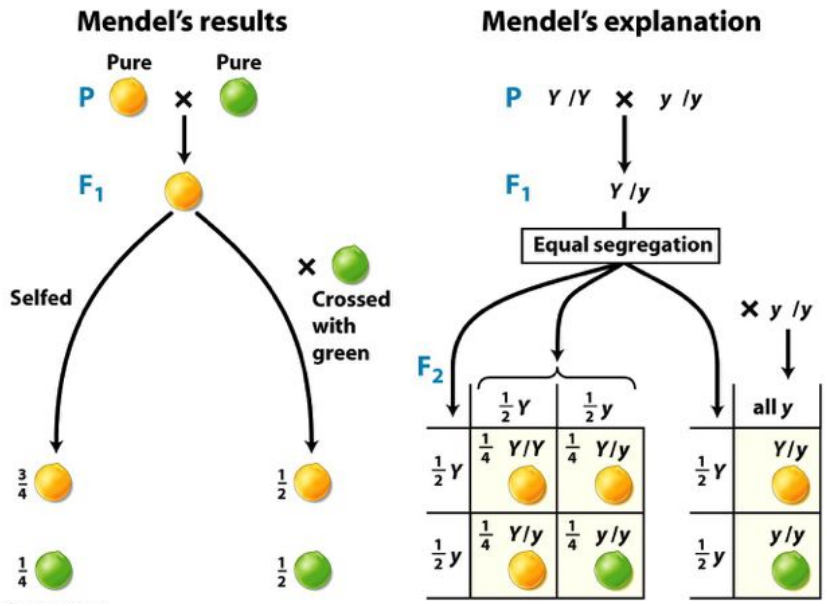


Mendel's Results

Even when PHENOTYPES are not so convenient to see, the SAME RULES OF SEGREGATION STILL HOLD TRUE for GENOTYPES!!!

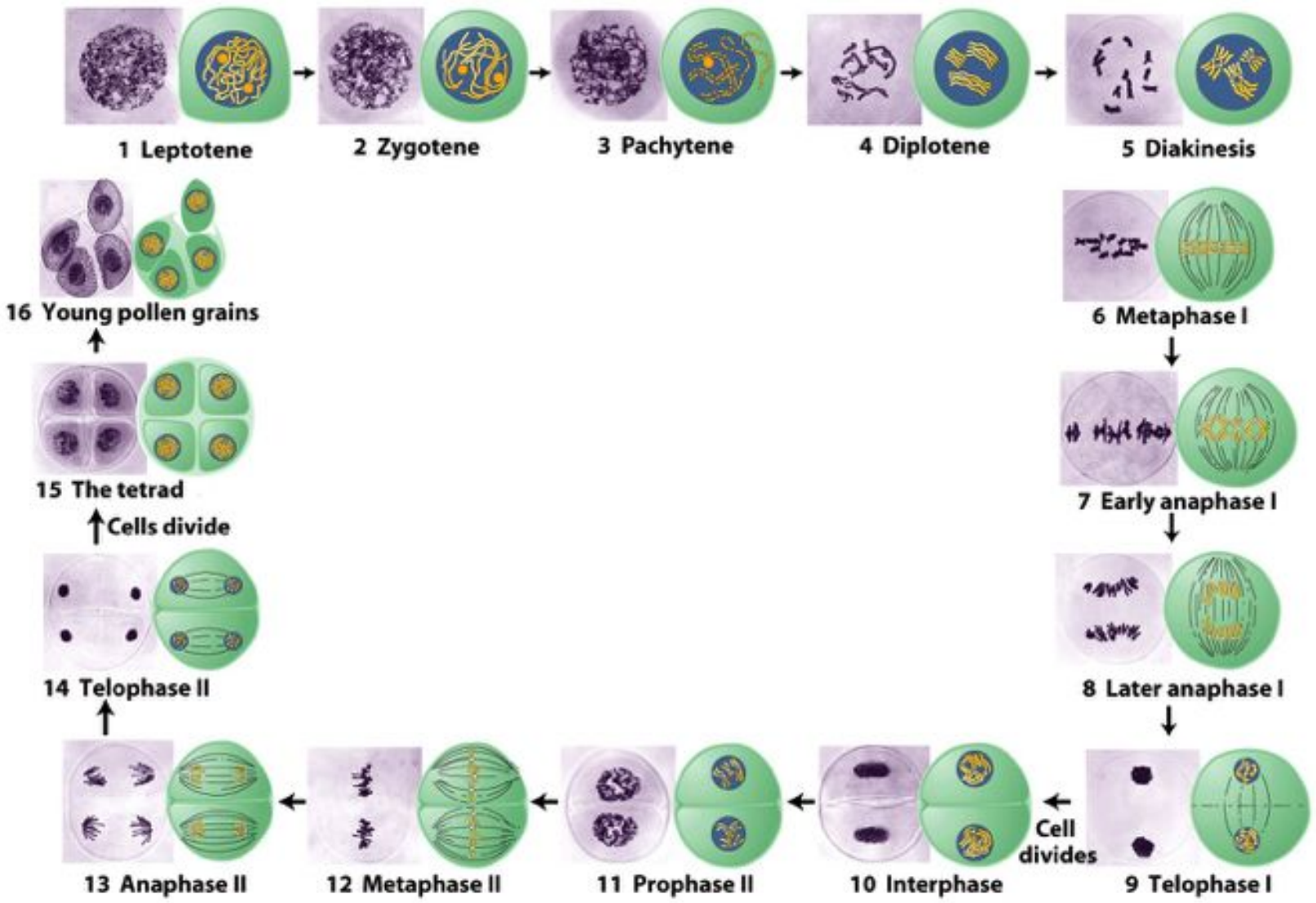
Notice that in the example below, there is no "DOMINANT" allele...you can see BOTH ALLELES when they are together. DNA changes are "CO-DOMINANT"





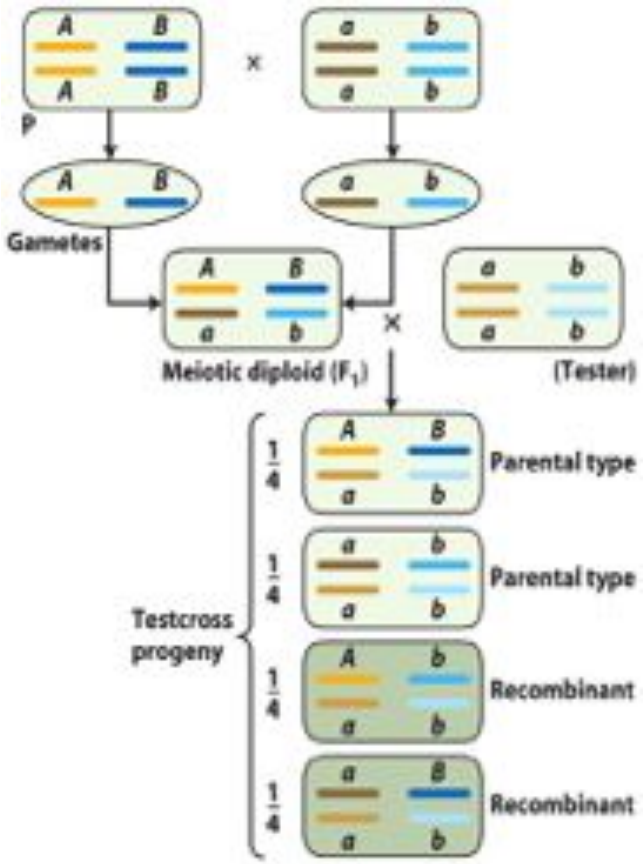
What Mendel was following are Genes on Chromosomes

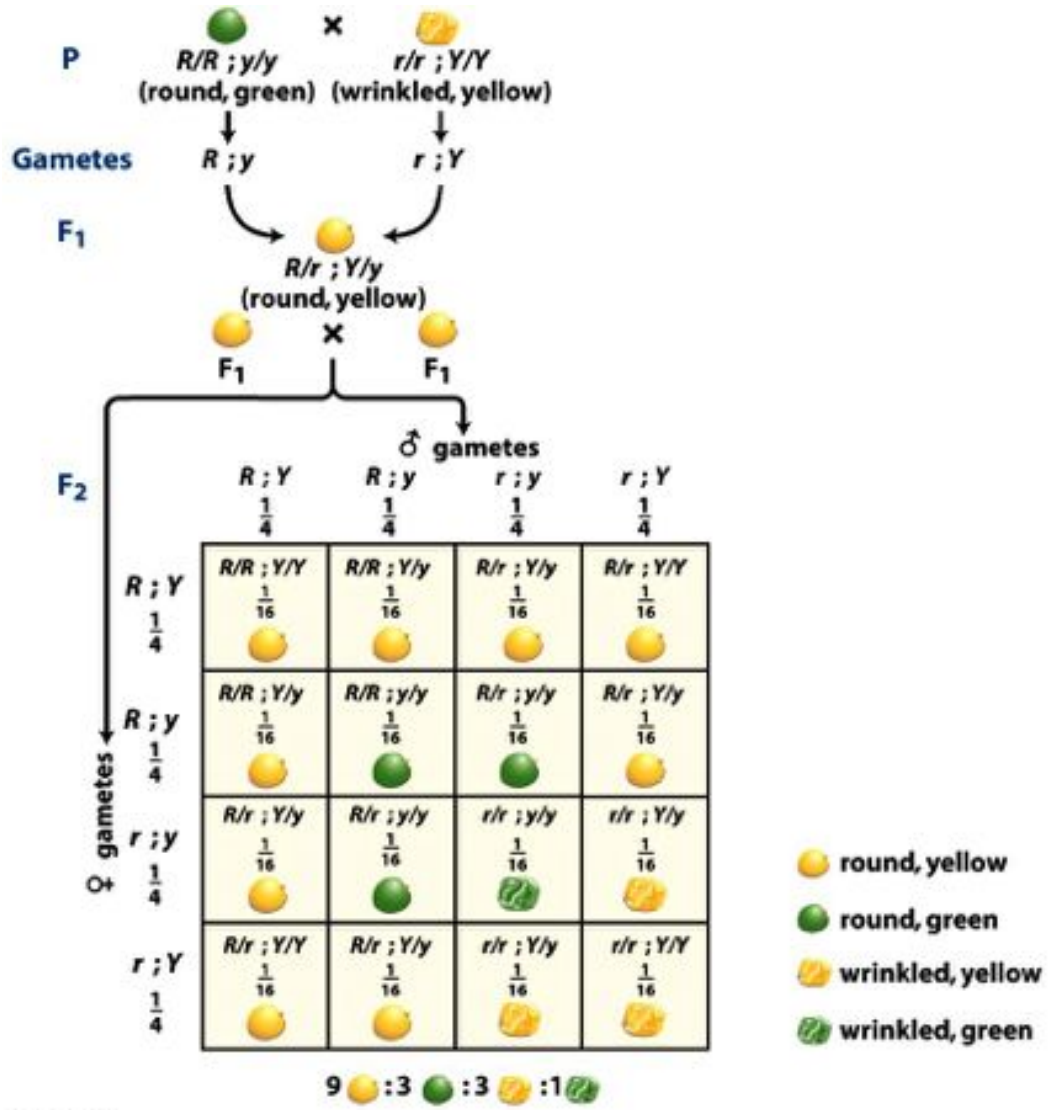
The way chromosomes turn out to move and segregate from each other in gamete formation matched Mendel's observations



More than one gene at a time

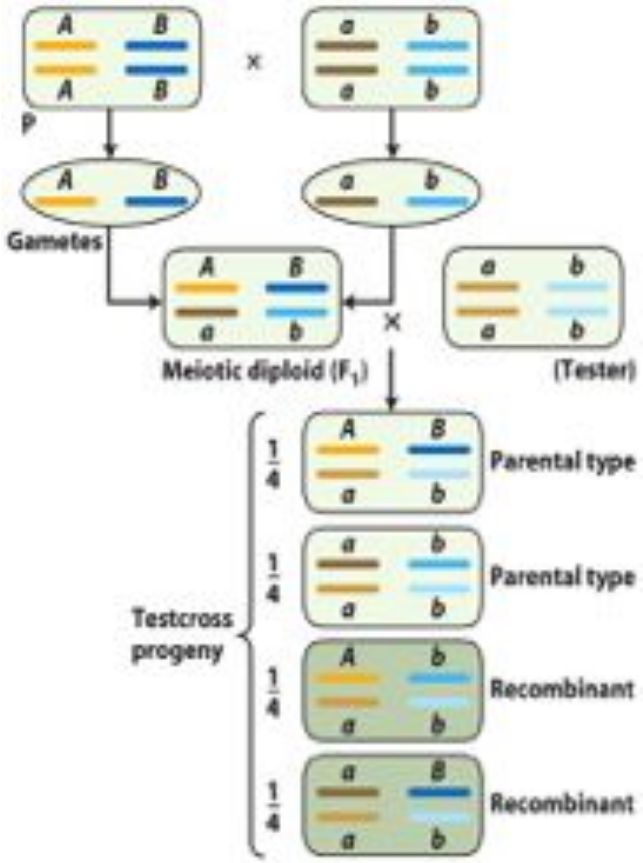
Alleles of two different genes that are each on <u>different</u> chromosomes are both inherited independently of one another ("unlinked")



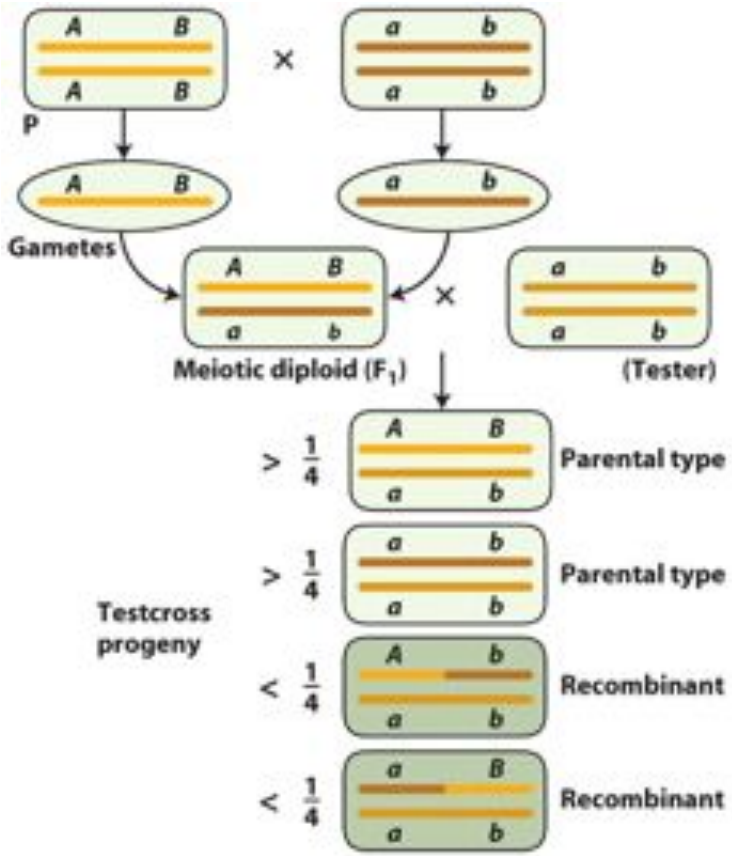


More than one gene at a time

Alleles of two different genes that are each on <u>different</u> chromosomes are both inherited but independently of one another ("unlinked")



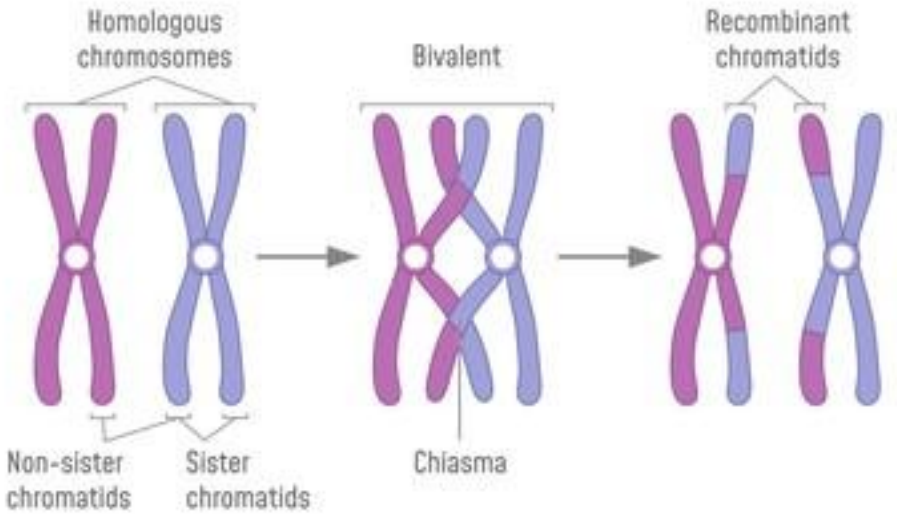
Alleles of two different genes that are located near one another on the <u>same</u> chromosome tend to be inherited together ("linked")



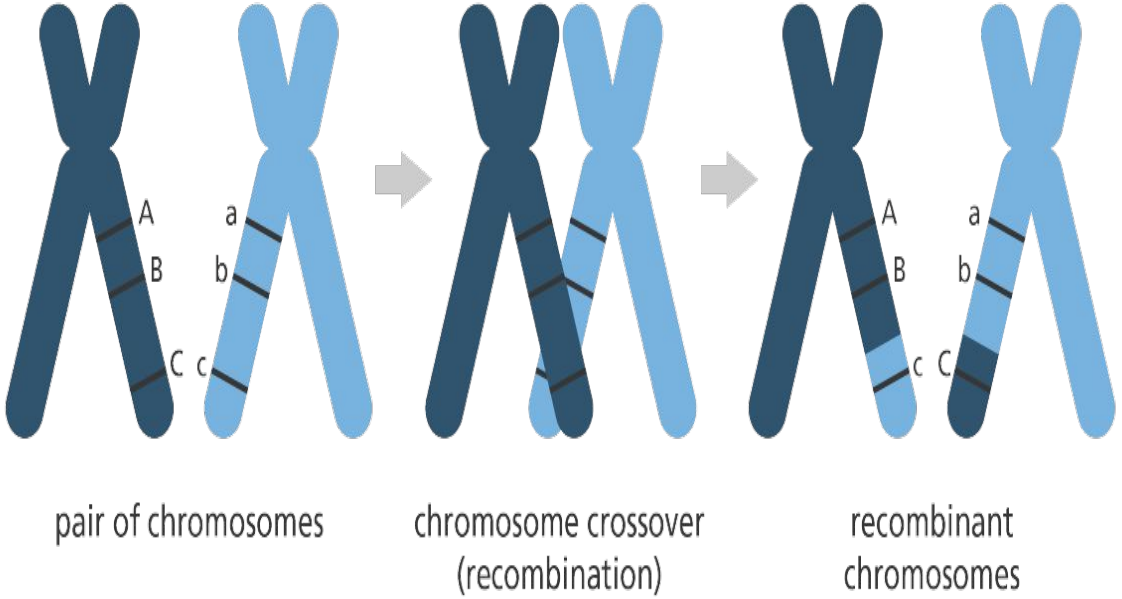
The closer two things are on a chromosome...

...the more likely they are to be inherited together

Pairs of chromosomes find each other during formation of sperm and eggs (meiosis), align and there is (on average) one physical exchange of DNA between each arm of each chromosome to hold them in place



The closer two things are on a chromosome, the less likely this exchange takes place in between them separating them from one another, and the more likely they remain together.



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A single base DNA sequence difference between two organisms (a Single Nucleotide Polymorphism (SNP)) can be linked to another DNA sequence difference that causes an interesting phenotype ("causative variation")

"ASSOCIATION STUDIES"

- Evaluate whether SNPs associate statistically with phenotype
  - Can use natural populations
  - The larger the population you look at, the more convincing any associations are that you find

A	C	G	A	G	1.3m
A	C	G	A	T	1.4m
A	T	A	A	G	1.5m
C	T	A	G	T	1.8m
A	C	G	G	T	2.0m
A	T	G	G	G	2.0m

The closer two things are on a chromosome...

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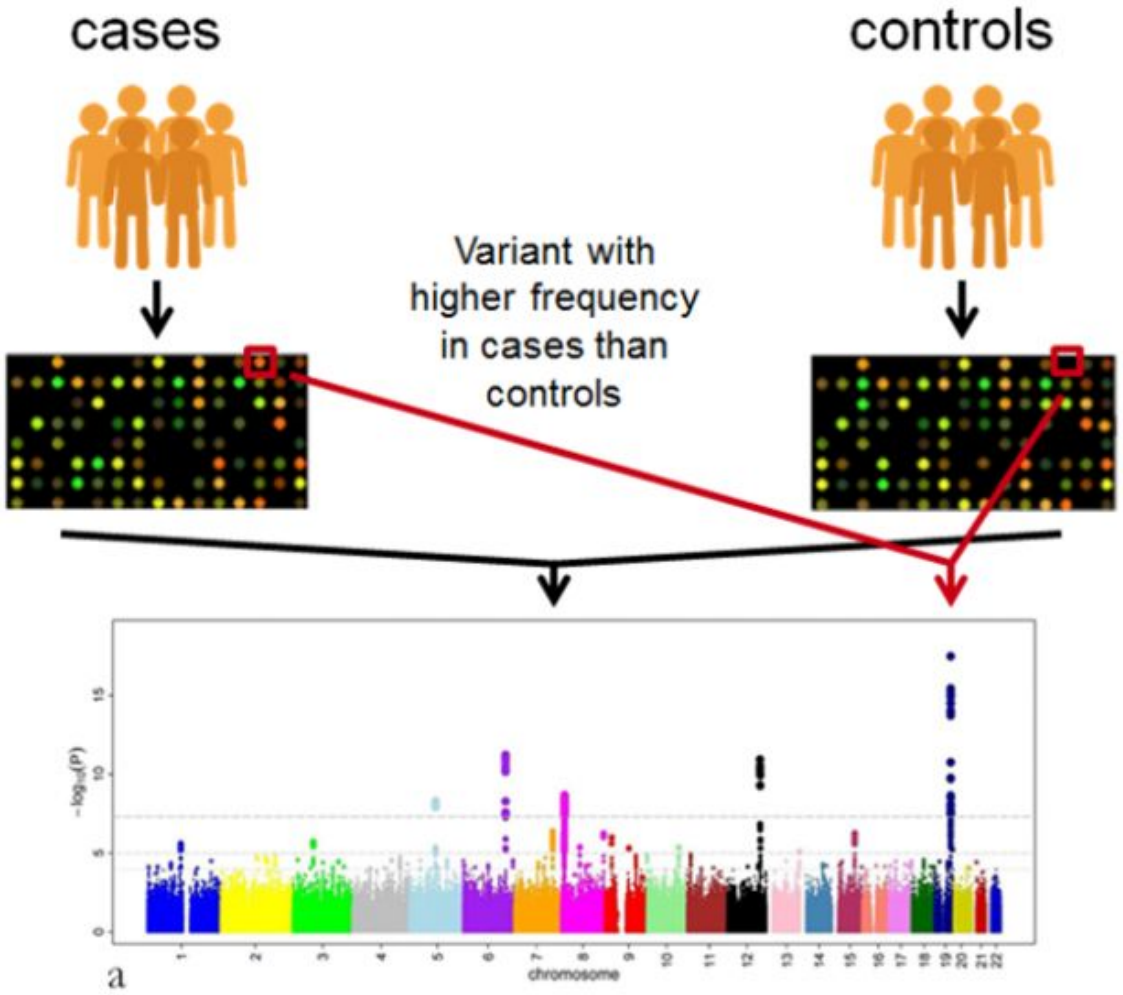
SO WHAT? WHO CARES?

Comparing two groups of organisms, look at the probability that each one of <u>many</u> SNPs *(tens or hundreds of thousands)* is associated with a trait

MOST are NOT associated, but...

Where they ARE allows us to identify regions of a genome that likely have one or more genes impacting that trait

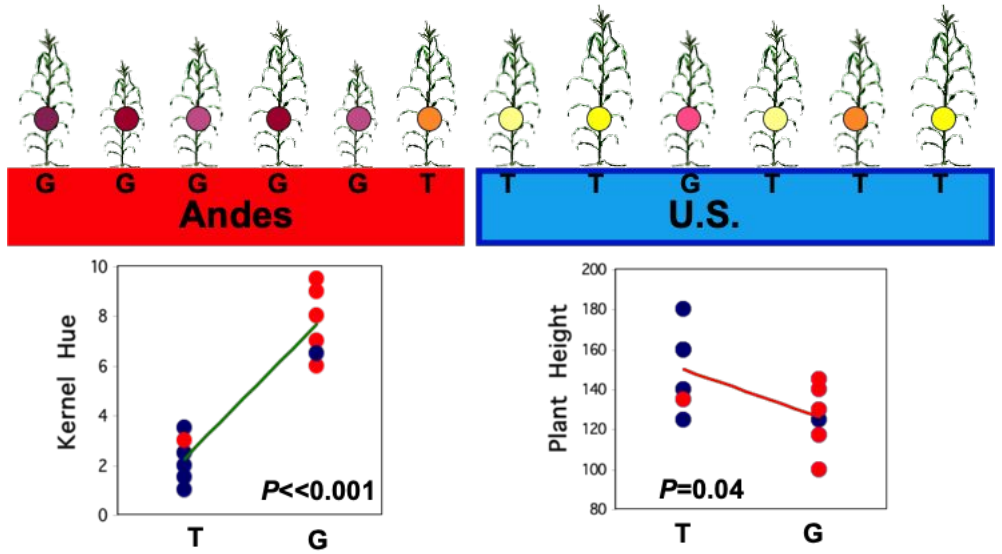


Associations may result from at least three causes

***1. The SNP *<u>IS the cause</u>* of the phenotype**

***2. The SNP is *<u>NEAR (linked to) the cause</u>* of the phenotype**

3. Population structure (Just means population is subdivided in some way) can produce false associations



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Discussion Questions

1. Do all alleles impact phenotype? Why or why not?

2. If they lack the enzyme made by the the *samoa-less* gene, humans cannot taste Girl Scout cookies. Would you predict such a mutation would be dominant or recessive? Why? How might you test your idea?

3. Why do you think peaks in Association Studies are usually stacks of points rather than just single points?