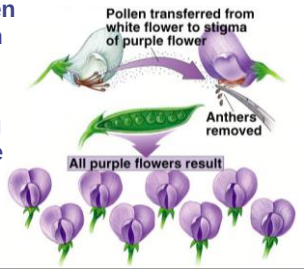
Chapter 12.1
Mendelian Genetics

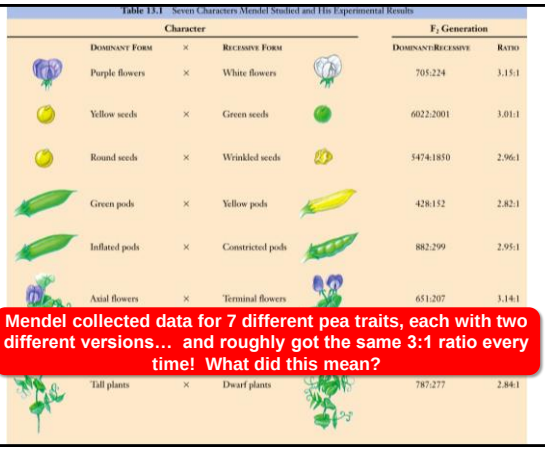
Gregor Mendel

- Modern genetics began in the mid-1800s in an abbey garden, where a monk named Gregor Mendel documented inheritance in peas
  - used experimental method
  - used quantitative analysis
    - collected data & counted them
  - excellent example of scientific method

Mendel's work

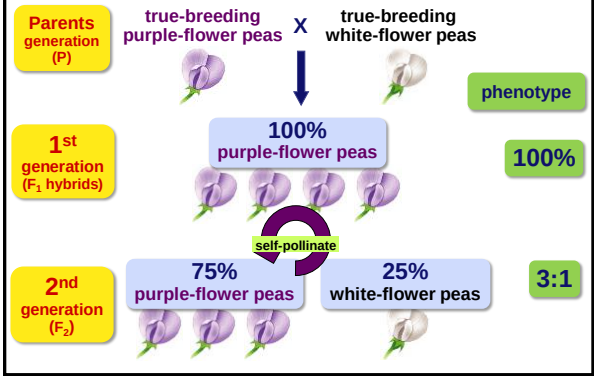
- Bred pea plants
  - cross-pollinated true breeding parents (P)
  - raised seed & then observed traits in hybrids (F_1)
    - filial
  - allowed offspring to cross-pollinate & observed next generation (F_2)





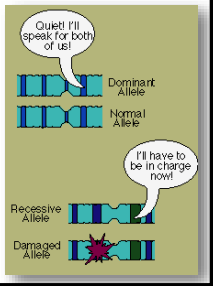
Mendel collected data for 7 different pea traits, each with two different versions… and roughly got the same 3:1 ratio every time! What did this mean?

Looking closer at Mendel's work



What did Mendel's findings mean?

- Some traits mask others
  - purple & white flower colors are separate traits that do not blend
    - purple x white ≠ light purple
    - purple masked white
  - dominant allele
    - fully expressed
  - recessive allele
    - no noticeable effect
    - the gene makes a non-functional protein

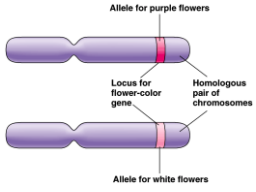


What did Mendel's findings mean?

- Traits come in alternative versions
  - purple vs. white flower color
  - alleles
    - different alleles vary in the sequence of nucleotides at the specific locus of a gene

purple-flower allele & white-flower allele are 2 DNA variations at flower-color locus

different versions of gene on homologous chromosomes



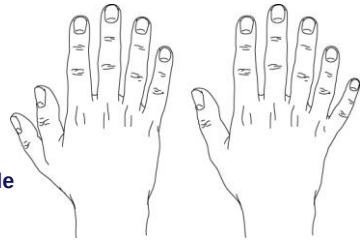
Traits are inherited as discrete units

- For each characteristic, a diploid organism inherits 2 alleles, 1 from each parent
  - diploid organism
    - inherits 2 sets of chromosomes, 1 from each parent
    - homologous chromosomes
    - like having 2 editions of encyclopedia
      - Encyclopedia Britannica
      - Encyclopedia Americana

Prevalence of Dominance

- Because an allele is dominant does not mean…
  - it is better
  - it is more common

Polydactyly: dominant allele



Polydactyly

Individuals are born with 'extra' fingers or toes!

Is dominant to the recessive allele for 5 digits…

Recessive allele far more common than dominant.

→399 individuals out of 400 have only 5 digits

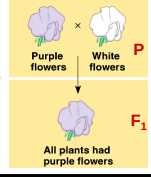
→most people are homozygous recessive (aa)

Hound Dog Taylor

Genotype vs. phenotype

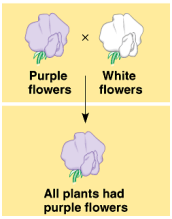
- difference between how an organism "looks" & its genetics
  - phenotype
    - description of an organism's trait
  - genotype
    - description of an organism's genetic makeup

Explain Mendel's results using phenotype & genotype dominant & recessive



Making crosses

- using representative letters
  - flower color alleles → P or *p*
  - true-breeding purple-flower peas → PP
  - true-breeding white-flower peas → *pp*



PP x *pp*

↓

Pp

Looking closer at Mendel's work

P: true-breeding purple-flower peas (PP) x true-breeding white-flower peas (*pp*)

↓

F_1 generation (hybrids): 100% purple-flower peas (*Pp* *Pp* *Pp* *Pp*)

self-pollinate

↓

F_2 generation: 75% purple-flower peas (? ? ?) 25% white-flower peas (?)

phenotype: 100% / 3:1

Punnett squares

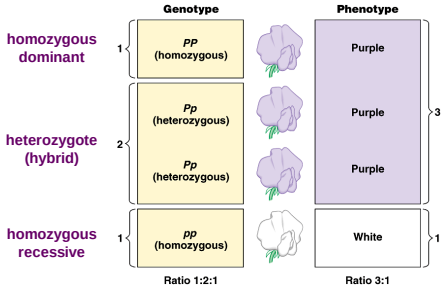
Pp x *Pp*

male / sperm →	P	*p*
female / eggs P	PP	*Pp*
female / eggs *p*	*Pp*	*pp*

	% genotype	% phenotype
PP	25%	75%
Pp	50%	
Pp		
pp	25%	25%
	1:2:1	3:1

Genotypes

- Homozygous = same alleles = PP, *pp*
- Heterozygous = different alleles = *Pp*



Phenotype vs. genotype

- 2 organisms can have the same phenotype but have different genotypes

purple	PP	homozygous dominant
purple	*Pp*	heterozygous

Dominant phenotypes

- It is not possible to determine the genotype of an organism with a dominant phenotype by looking at it.

PP?

Pp?

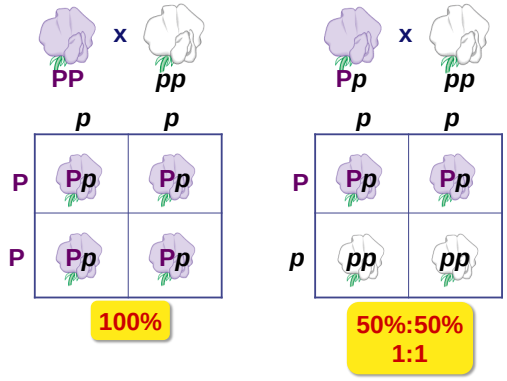
Test cross

- Cross-breed the dominant phenotype — and unknown genotype — with a homozygous recessive (*pp*) to determine the identity of the unknown allele

is it PP or P*p*?

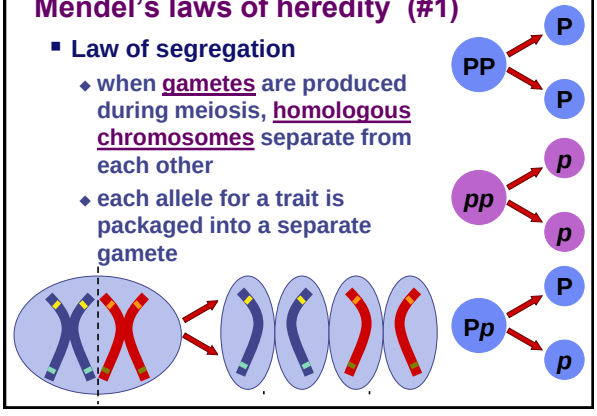
pp

Test cross



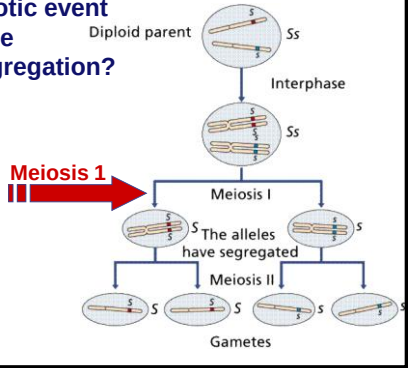
Mendel's laws of heredity (#1)

- Law of segregation
  - when gametes are produced during meiosis, homologous chromosomes separate from each other
  - each allele for a trait is packaged into a separate gamete



Law of Segregation

- What meiotic event creates the law of segregation?

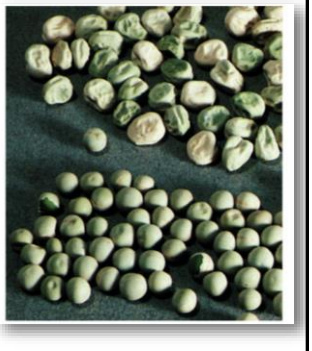


Monohybrid cross

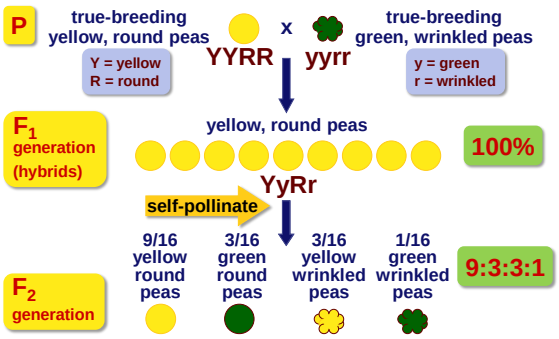
- Some of Mendel's experiments followed the inheritance of single characters
  - flower color
  - seed color
  - monohybrid crosses

Dihybrid cross

- Other of Mendel's experiments followed the inheritance of 2 different characteristics
  - dihybrid crosses
  - seed color and seed shape

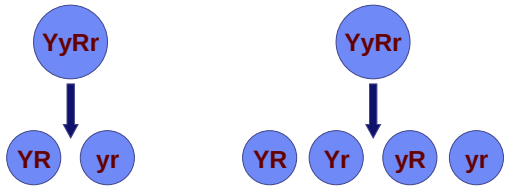


Dihybrid cross



What's going on here?

- How are the alleles for different traits "handed out"?
  - together or separately?



Dihybrid cross

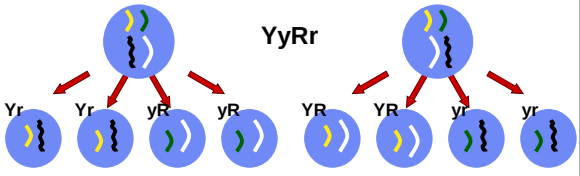
YyRr x YyRr

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

9/16 yellow round
3/16 green round
3/16 yellow wrinkled
1/16 green wrinkled

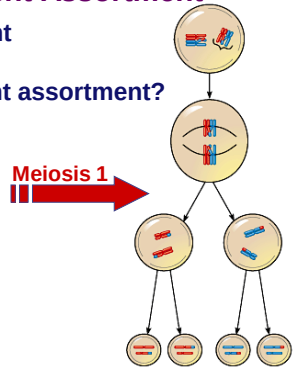
Mendel's laws of heredity (#2)

- Law of independent assortment
  - each pair of alleles segregates into gametes independently
    - 4 classes of gametes are produced in equal amounts
      - YR, Yr, yR, yr
    - only true for genes on separate chromosomes



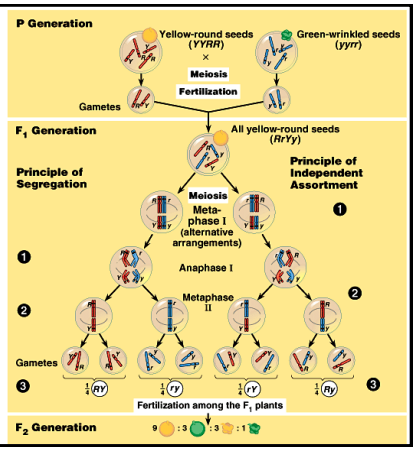
Law of Independent Assortment

- What meiotic event creates the law of independent assortment?



The chromosomal basis of Mendel's laws…

Trace the genetic events through meiosis, gamete formation & fertilization to offspring!



Review: Mendel's laws of heredity

- Law of segregation
  - monohybrid cross
    - single trait
  - each allele segregates into separate gametes
    - established by Meiosis 1
- Law of independent assortment
  - dihybrid (or more) cross
    - 2 or more traits
  - each pair of alleles for genes on separate chromosomes segregates into gametes independently
    - established by Meiosis 1

Mendel chose peas wisely

- Pea plants are good for genetic research
  - available in many varieties with distinct heritable features with different variations
    - flower color, seed color, seed shape, etc.
  - Mendel had strict control over which plants mated with which
    - each pea plant has male & female structures
    - pea plants can self-fertilize
    - Mendel could also cross-pollinate plants: moving pollen from one plant to another

Mendel chose peas luckily…

- Pea plants are good for genetic research
  - relatively simple genetically
    - most characters are controlled by a single gene
    - each gene has only 2 alleles, one of which is completely dominant over the other