Chapter 14.

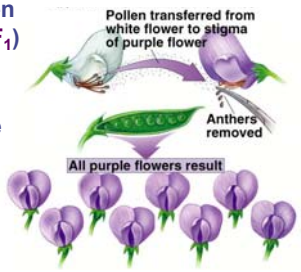
Mendel & Genetics

Gregor Mendel

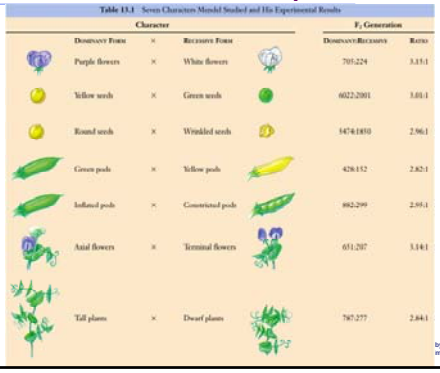
- Modern genetics began in the mid-1800s in an abbey garden, where a monk named Gregor Mendel documented inheritance in peas
  - used experimental method
  - used quantitative analysis
    - collected data & counted them
  - excellent example of scientific method

Mendel's work

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



Mendel collected data for 7 pea traits



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by K. Foglia
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Looking closer at Mendel's work

P: true-breeding purple-flower peas X true-breeding white-flower peas

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

self-pollinate

F_2 generation: 75% purple-flower peas — 25% white-flower peas — 3:1

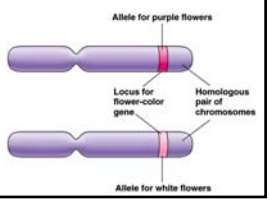
Based on work by K. Foglia
www.kimunity.com

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



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Traits are inherited as discrete units

- For each characteristic, an 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

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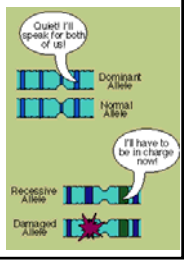
What did Mendel's findings mean?

- 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



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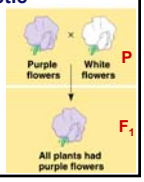
Genotype vs. phenotype

- 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
…dominant & recessive
…phenotype & gentotype



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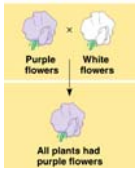
Making crosses

- 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

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Based on work by K. Foglia
www.kimunity.com

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***

phenotype: **100%**

self-pollinate

F$_2$ generation

75% purple-flower peas ? ? ?

25% white-flower peas ?

3:1

Based on work by K. Foglia
www.kimunity.com

Punnett squares

Pp x ***Pp***

male / sperm: **P** **p**

female / eggs: **P** **p**

	P	p
P	PP	*Pp*
p	*Pp*	*pp*

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

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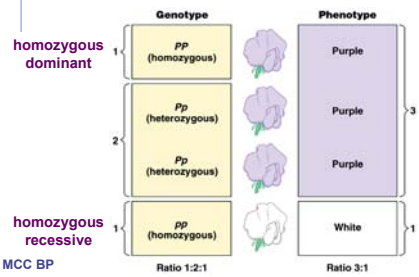
Genotypes

- Homozygous = same alleles = PP, *pp*
- Heterozygous = different alleles = P*p*



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Phenotype vs. genotype

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


purple PP homozygous dominant


purple P*p* heterozygous

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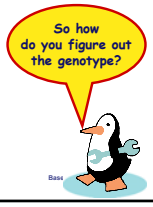
Dominant phenotypes

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

PP?

Pp?



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Test cross

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

is it PP or P*p*?

pp

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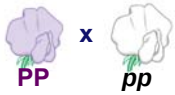
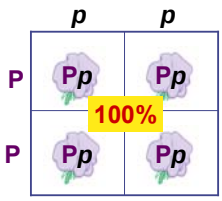
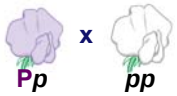
Test cross

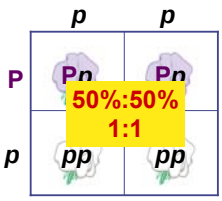


PP x *pp*





Pp x *pp*



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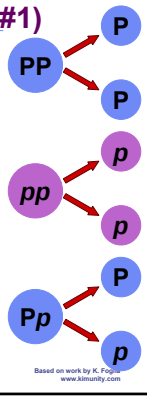
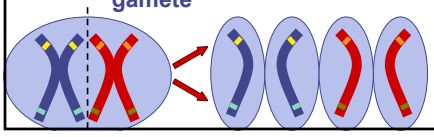
Mendel's laws of heredity (#1)

- 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





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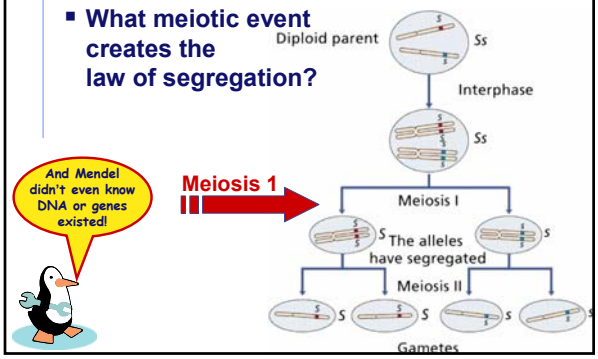
Law of Segregation

- What meiotic event creates the law of segregation?

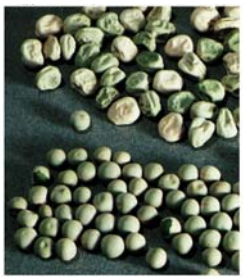


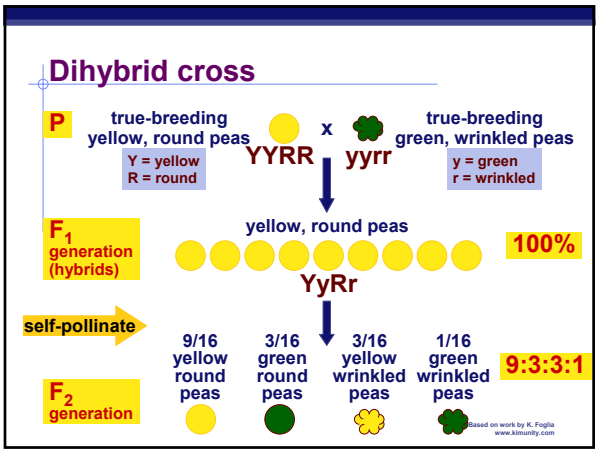
Monohybrid cross

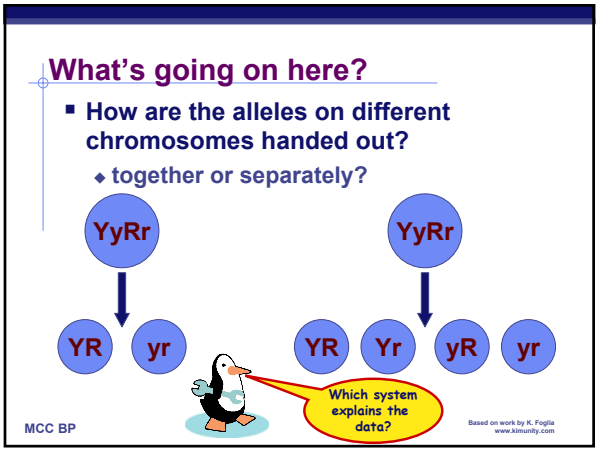
- Some of Mendel's experiments followed the inheritance of single characters
  - flower color
  - seed color
  - monohybrid crosses

Dihybrid cross

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




Dihybrid cross
P
true-breeding yellow, round peas
Y = yellow
R = round
YYRR
x
yyrr
true-breeding green, wrinkled peas
y = green
r = wrinkled
F1 generation (hybrids)
yellow, round peas
100%
YyRr
self-pollinate
F2 generation
9/16 yellow round peas
3/16 green round peas
3/16 yellow wrinkled peas
1/16 green wrinkled peas
9:3:3:1
Based on work by K. Foglia
www.kimunity.com


What's going on here?
How are the alleles on different chromosomes handed out?
together or separately?
YyRr
YyRr
YR
yr
YR
Yr
yR
yr
Which system explains the data?
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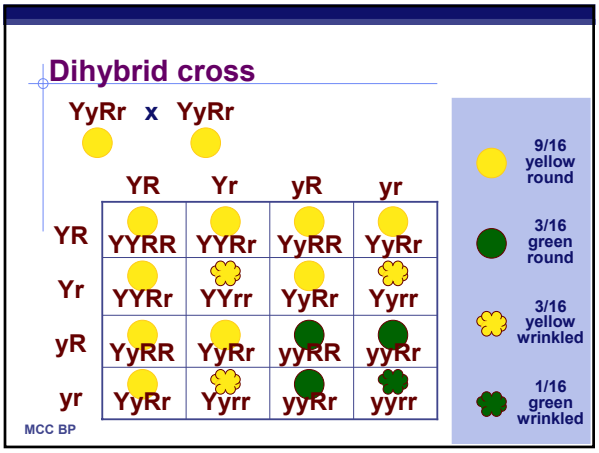
Dihybrid cross
YyRr x YyRr
YR
Yr
yR
yr
YYRR
YYRr
YyRR
YyRr
YYRr
YYrr
YyRr
Yyrr
YyRR
YyRr
yyRR
yyRr
YyRr
Yyrr
yyRr
yyrr
9/16 yellow round
3/16 green round
3/16 yellow wrinkled
1/16 green wrinkled
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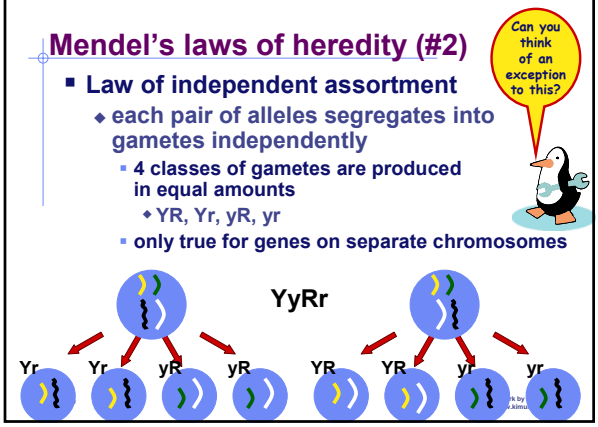
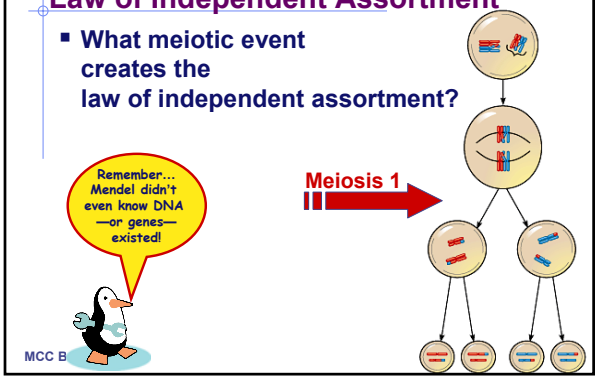
Mendel's laws of heredity (#2)

- 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



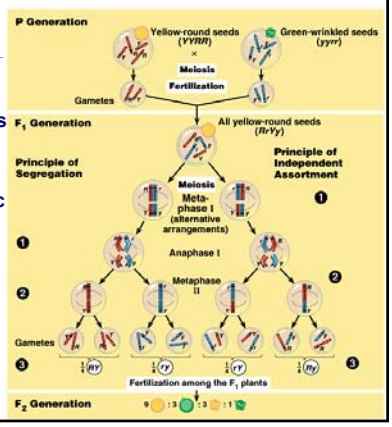
Law of Independent Assortment

- 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



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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

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Based on work by K. Foglia
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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

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Based on work by K. Foglia
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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

Gregor Mendel

Any Questions??

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