Chapter 14.

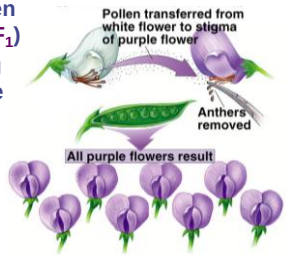
Mendel & Genetics

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)
  - allowed offspring to cross-pollinate & observed next generation (F_2)

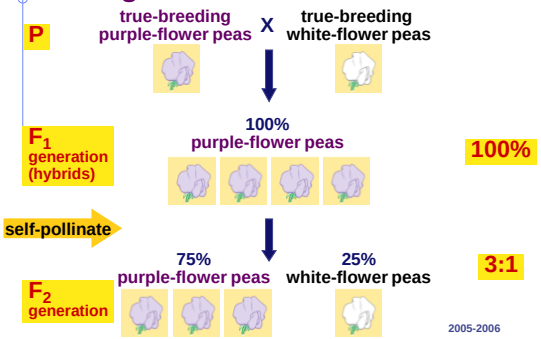


Mendel collected data for 7 pea traits

Table 13.1 Seven Characters Mendel Studied and His Experimental Results

Character	Dominant Form	×	Recessive Form	F_2 Generation Dominant:Recessive	Ratio
Purple flowers		×	White flowers	705:224	3.15:1
Yellow seeds		×	Green seeds	6022:2001	3.01:1
Round seeds		×	Wrinkled seeds	5474:1850	2.96:1
Green pods		×	Yellow pods	428:152	2.82:1
Inflated pods		×	Constricted pods	882:299	2.95:1
Axial flowers		×	Terminal flowers	651:207	3.14:1
Tall plants		×	Dwarf plants	787:277	2.84:1

Looking closer at Mendel's work

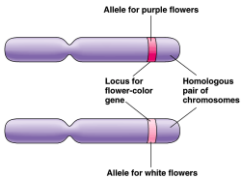


What did Mendel's findings mean?

- 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

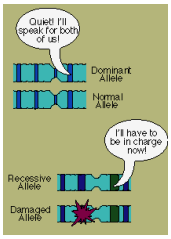


Traits are inherited as discrete units

- For each characteristic, an organism inherits 2 alleles, 1 from each parent
  - diploid organism
    - inherits 2 sets of chromosomes, 1 from each parent
    - homologous chromosomes

What did Mendel's findings mean?

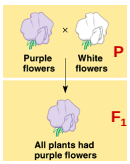
- Some traits mask others
  - purple & white flower colors are separate traits that do not blend
    - purple x white ≠ light purple
    - purple masked white
  - dominant allele
    - fully expressed
  - recessive allele
    - no noticeable effect
    - the gene makes a non-functional protein



Genotype vs. phenotype

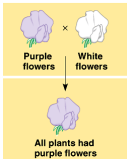
- difference between how an organism "looks" & its genetics
  - phenotype
    - description of an organism's trait
  - genotype
    - description of an organism's genetic makeup

Explain Mendel's results using
…dominant & recessive
…phenotype & gentotype



Making crosses

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

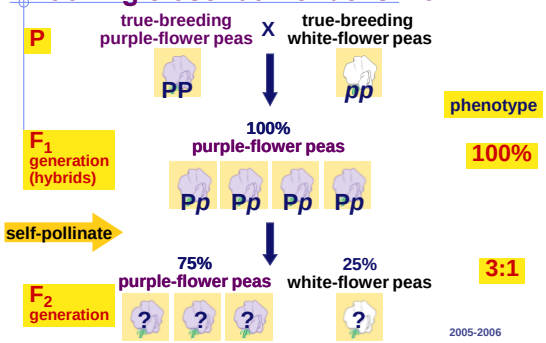


PP x *pp*

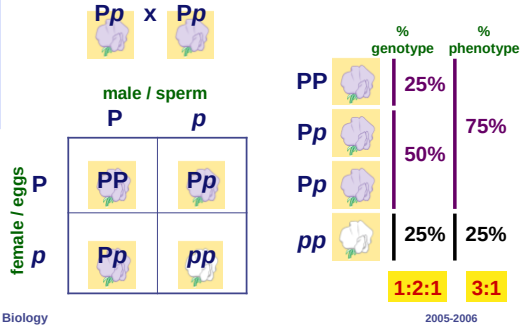
↓

Pp

Looking closer at Mendel's work

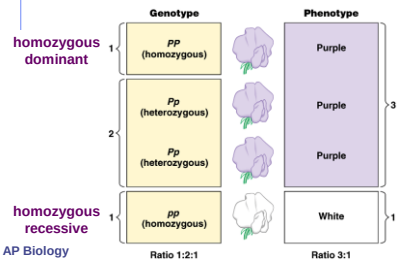


Punnett squares



Genotypes

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



Phenotype vs. genotype

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

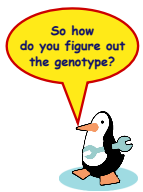
purple	PP	homozygous dominant
purple	P*p*	heterozygous

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

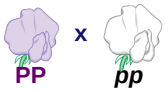
- Cross-breed the dominant phenotype — unknown genotype — with a homozygous recessive (*pp*) to determine the identity of the unknown allele

is it PP or P*p*?

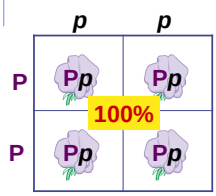
x

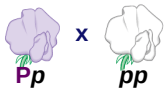
pp

Test cross

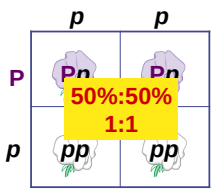


PP x *pp*



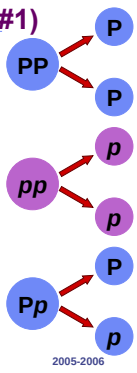


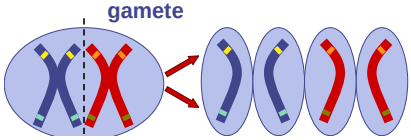
Pp x *pp*



Mendel's laws of heredity (#1)

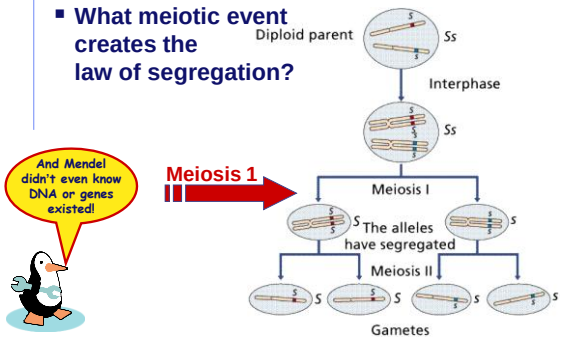
- Law of segregation
  - when gametes are produced during meiosis, homologous chromosomes separate from each other
  - each allele for a trait is packaged into a separate gamete





Law of Segregation

- What meiotic event creates the law of segregation?

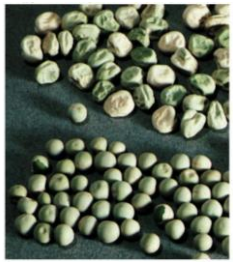


Monohybrid cross

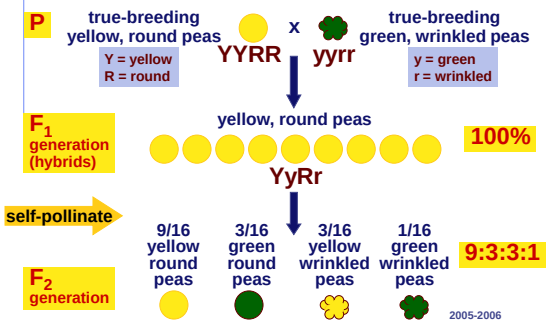
- Some of Mendel's experiments followed the inheritance of single characters
  - flower color
  - seed color
  - monohybrid crosses

Dihybrid cross

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

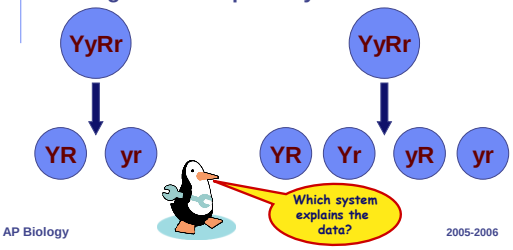


Dihybrid cross

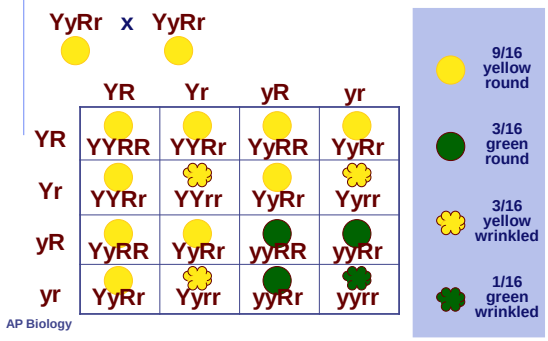


What's going on here?

- How are the alleles on different chromosomes handed out?
  - together or separately?

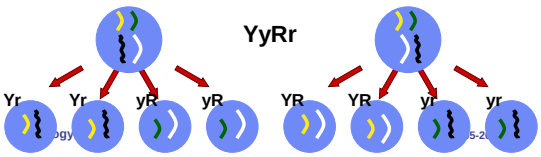


Dihybrid cross



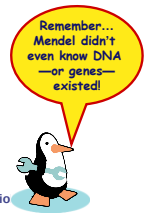
Mendel's laws of heredity (#2)

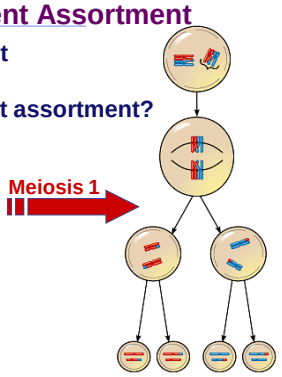
- Law of independent assortment
  - each pair of alleles segregates into gametes independently
    - 4 classes of gametes are produced in equal amounts
      - YR, Yr, yR, yr
    - only true for genes on separate chromosomes



Law of Independent Assortment

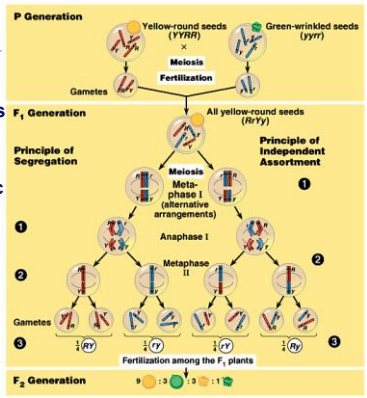
- What meiotic event creates the law of independent assortment?





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

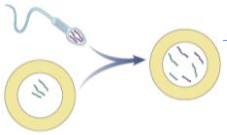
Mendel chose peas luckily

- 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


Gregor Mendel

Chapter 14.

Probability & Genetics



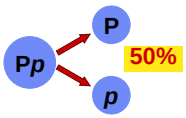
Genetics & Probability

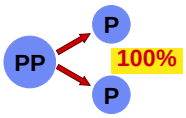
- Mendel's laws:
  - segregation
  - independent assortment

reflect same laws of probability that apply to tossing coins or rolling dice

Probability & genetics

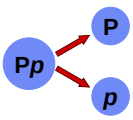
- Calculating probability of making a specific gamete is just like calculating the probability in flipping a coin
  - probability of tossing heads? 50%
  - probability making a **P** gamete…





Probability & genetics

- Outcome of 1 toss has no impact on the outcome of the next toss
  - probability of tossing heads each time? 50%
  - probability making a **P** gamete each time? 50%



Calculating probability

Pp x Pp

male / sperm

female / eggs	P	p
P	PP	Pp
p	Pp	pp

sperm	egg	offspring
P 1/2	x P 1/2 =	PP 1/4
P 1/2	x *p* 1/2 =	*Pp* 1/4
p 1/2	x P 1/2 =	1/4
		1/2
p 1/2	x *p* 1/2 =	*pp* 1/4

Rule of multiplication

- Chance that 2 or more independent events will occur together
  - probability that 2 coins tossed at the same time will land heads up

1/2 x 1/2 = 1/4

  - probability of Pp x Pp → pp

1/2 x 1/2 = 1/4

Calculating dihybrid probability

- Rule of multiplication also applies to dihybrid crosses
  - heterozygous parents — YyRr
  - probability of producing yyrr?
    - probability of producing y gamete = 1/2
    - probability of producing r gamete = 1/2
    - probability of producing yr gamete = 1/2 x 1/2 = 1/4
    - probability of producing a yyrr offspring = 1/4 x 1/4 = 1/16

Rule of addition

- Chance that an event can occur 2 or more different ways
  - sum of the separate probabilities
  - probability of Pp x Pp → Pp

sperm		egg		offspring
P 1/2	x	p 1/2	=	Pp 1/4
p 1/2	x	P 1/2	=	Pp 1/4

1/4 + 1/4 = 1/2

Chi-square test

- Test to see if your data supports your hypothesis
- Compare "observed" vs. "expected" data
  - is variance from expected due to "random chance"?
  - is there another factor influencing data?
    - null hypothesis
    - degrees of freedom
    - statistical significance

Any Questions??