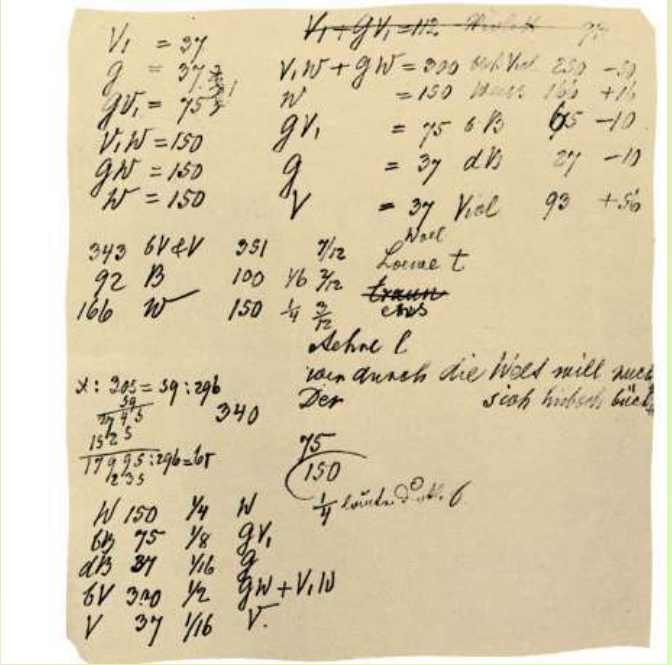
Genetics
&
The Work of Mendel
(Ch. 14)

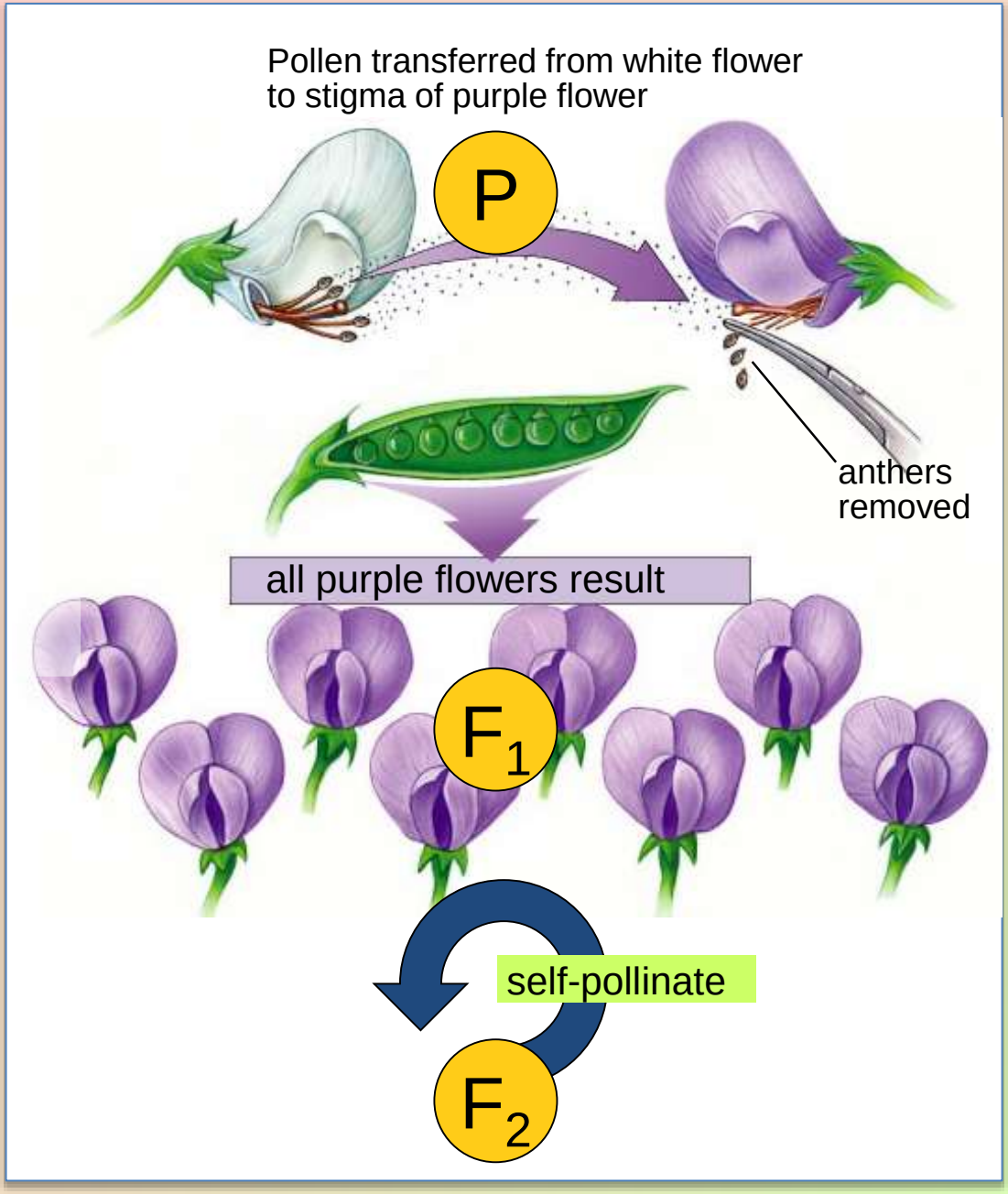
Gregor Mendel

- 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-pollinate true breeding parents (P)
    - P = parental
  - raised seed & then observed traits (F_1)
    - F = filial
  - allowed offspring to self-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				F_2 Generation	
Dominant Form	×	Recessive Form		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

P

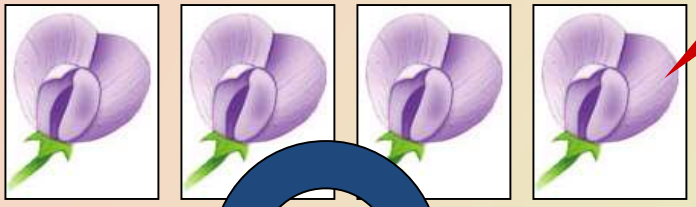
true-breeding purple-flower peas

X

true-breeding white-flower peas

F_1 generation (hybrids)

100% purple-flower peas



Where did the white flowers go?

100%

self-pollinate

F_2 generation

75% purple-flower peas

25% white-flower peas

White flowers came back!

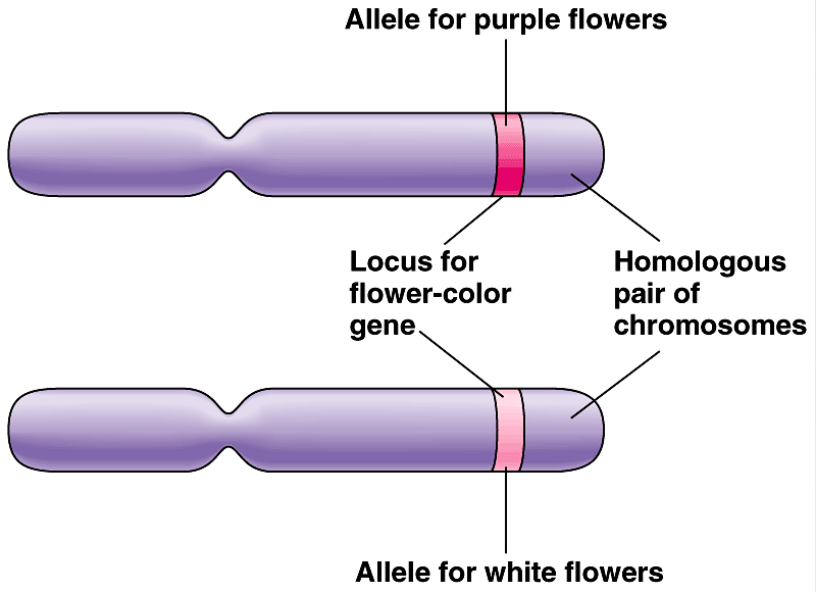
3:1

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
      - some difference in sequence of A, T, C, G

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

different versions of gene at same location on homologous chromosomes



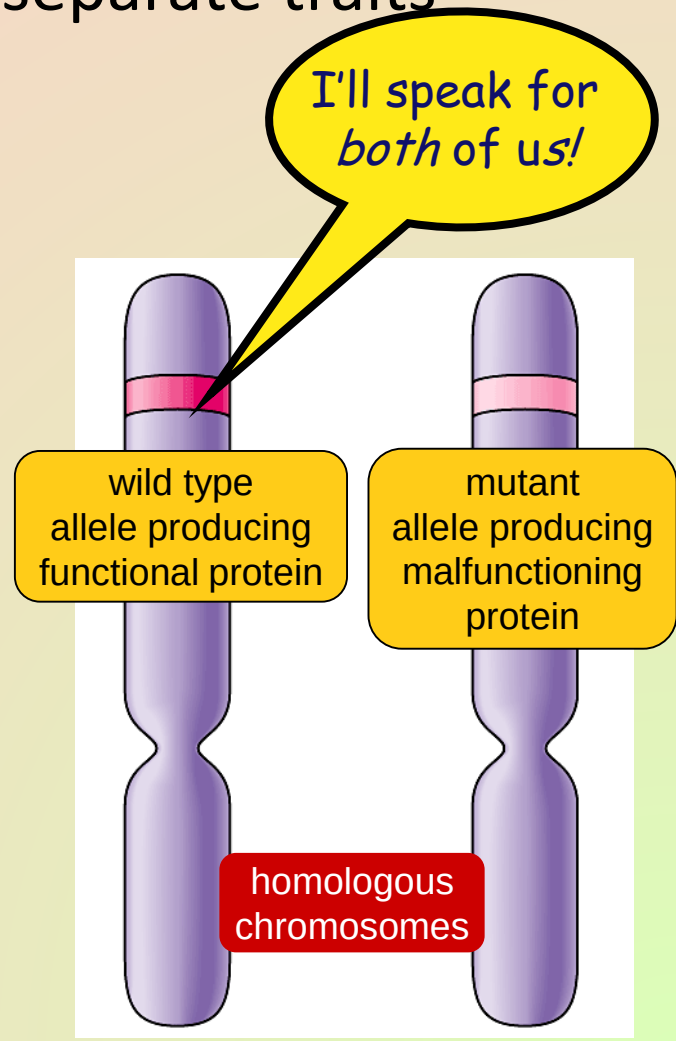
Traits are inherited as discrete units

- 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
    - like having 2 editions of encyclopedia
      - Encyclopedia Britannica
      - Encyclopedia Americana

What are the advantages of being diploid?

What did Mendel's findings mean?

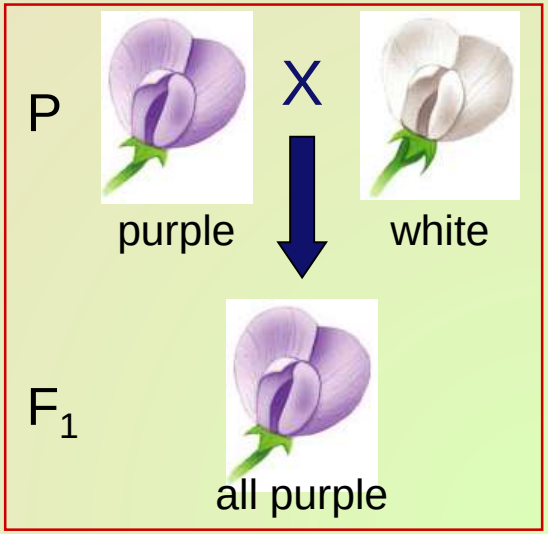
- Some traits mask others
  - purple & white flower colors are separate traits that do not blend
    - purple x white ≠ light purple
    - purple masked white
  - dominant allele
    - functional protein
    - masks other alleles
  - recessive allele
    - allele makes a malfunctioning protein



Genotype vs. phenotype

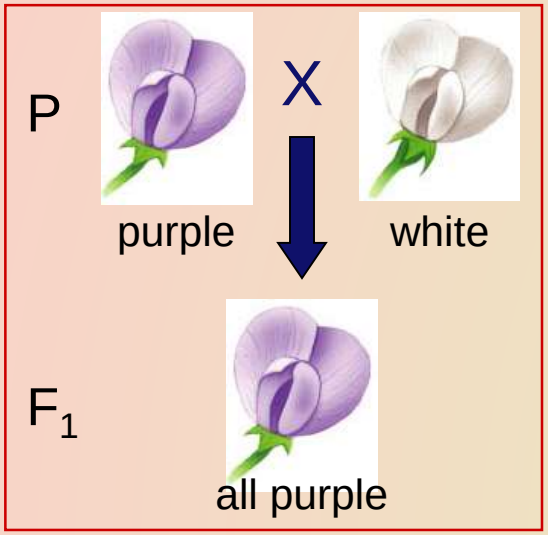
- Difference between how an organism "looks" & its genetics
  - phenotype
    - description of an organism's trait
    - the "physical"
  - genotype
    - description of an organism's genetic makeup

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



Making crosses

- Can represent alleles as 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

phenotype

genotype

F_1 generation (hybrids)

100% purple-flower peas

Pp *Pp* *Pp* *Pp*

100%

self-pollinate

F_2 generation

75% purple-flower peas

? ? ?

25% white-flower peas

?

3:1

Punnett squares

F_1 generation (hybrids)

Pp x Pp


male / sperm

female / eggs	P	p
P	PP	Pp
p	Pp	pp

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

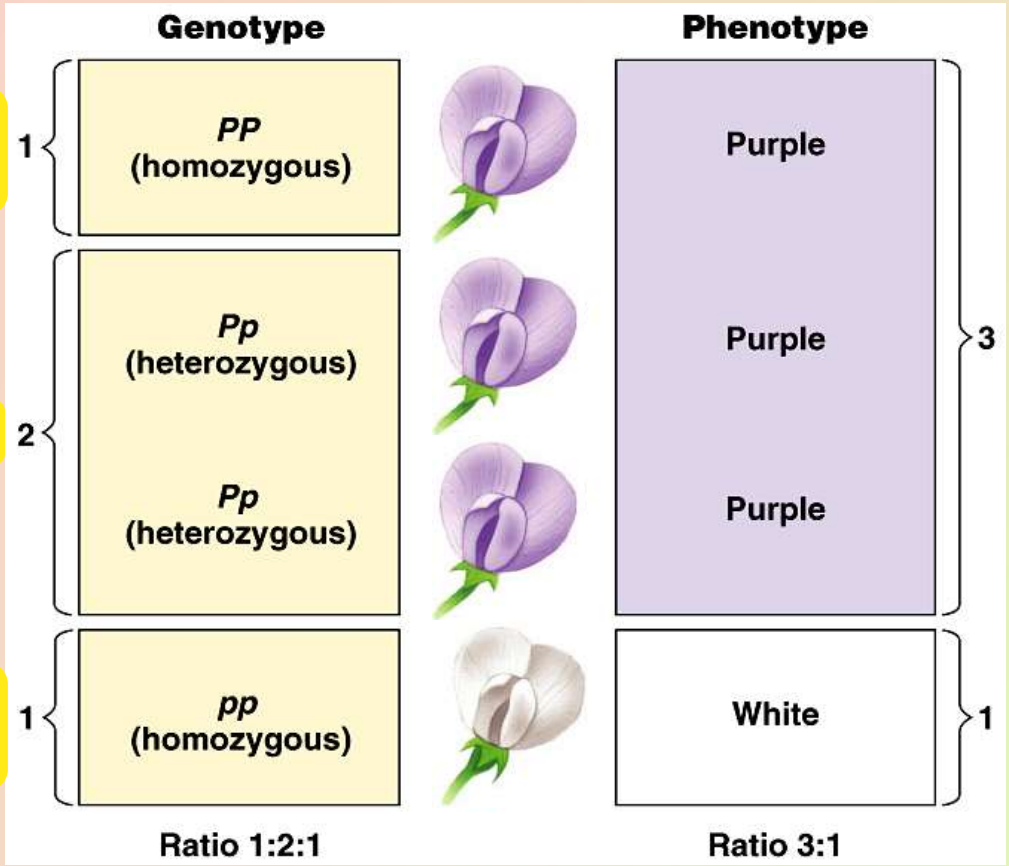
Genotypes

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

homozygous dominant

heterozygous

homozygous recessive



Phenotype vs. genotype

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

purple PP homozygous dominant

purple P*p* heterozygous

How do you determine the genotype of an individual with with a dominant phenotype?

Test cross

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

x

is it
PP or P*p*?

pp

How does a Test cross work?

Am I this?

PP

x

pp

Or am I this?

P*p*

x

pp

	p	*p*
P	P*p*	P*p*
P	P*p*	P*p*

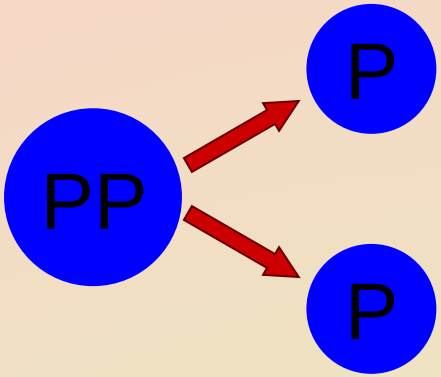
100% purple

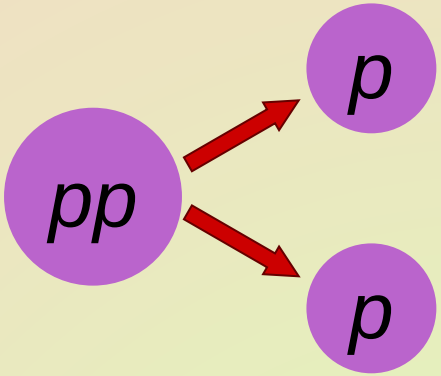
	p	*p*
P	P*p*	P*p*
p	*pp*	*pp*

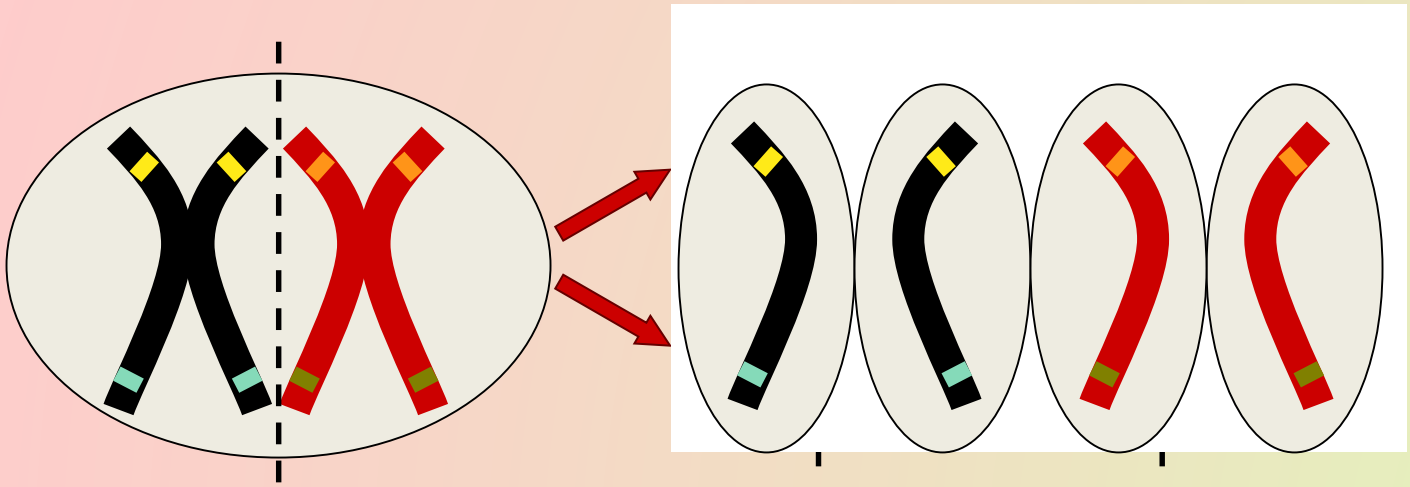
50% purple:50% white or 1:1

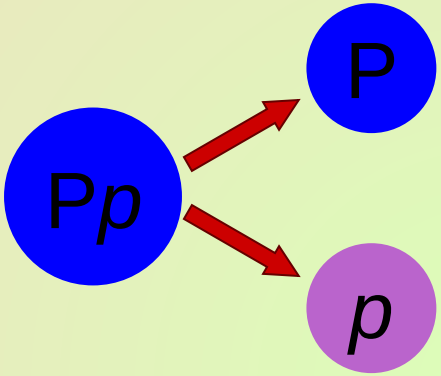
Mendel's 1st law of heredity

- Law of segregation
  - during meiosis, alleles segregate
    - homologous chromosomes separate
  - each allele for a trait is packaged into a separate gamete





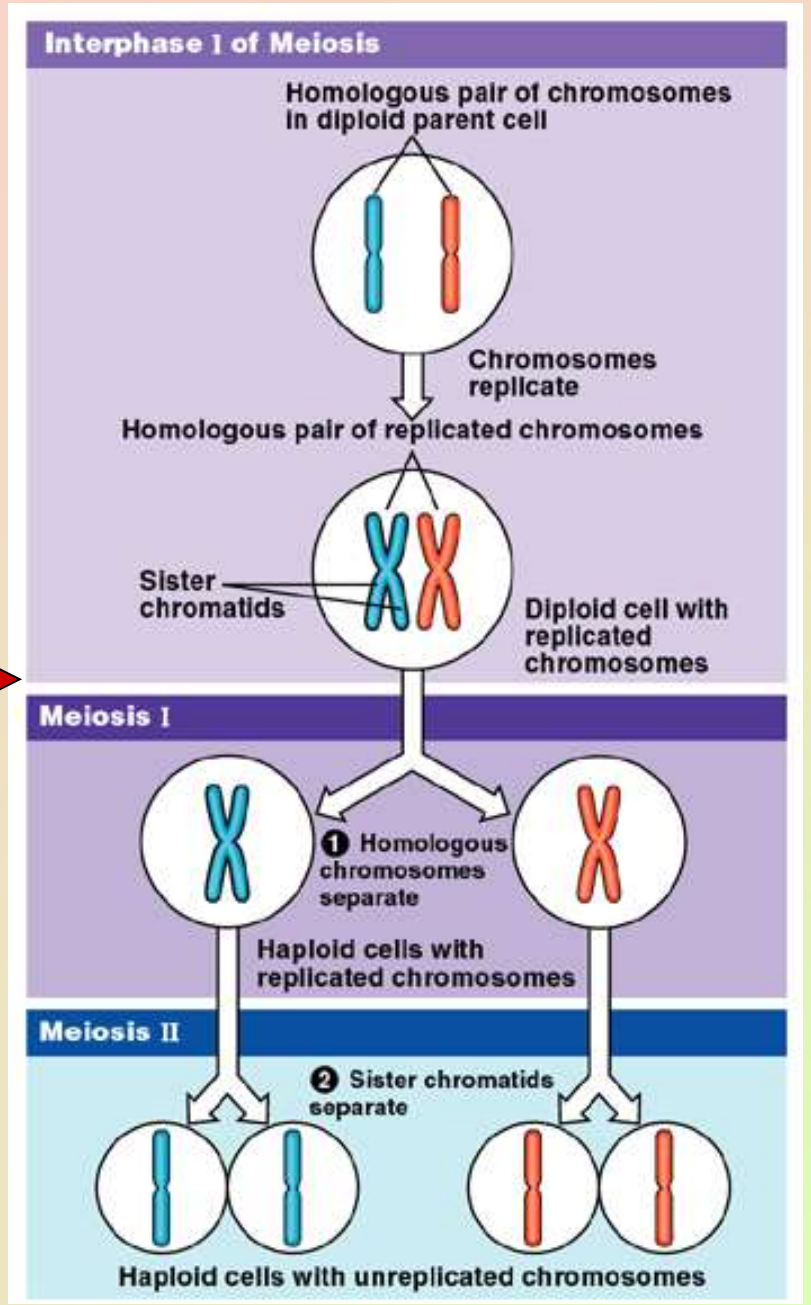


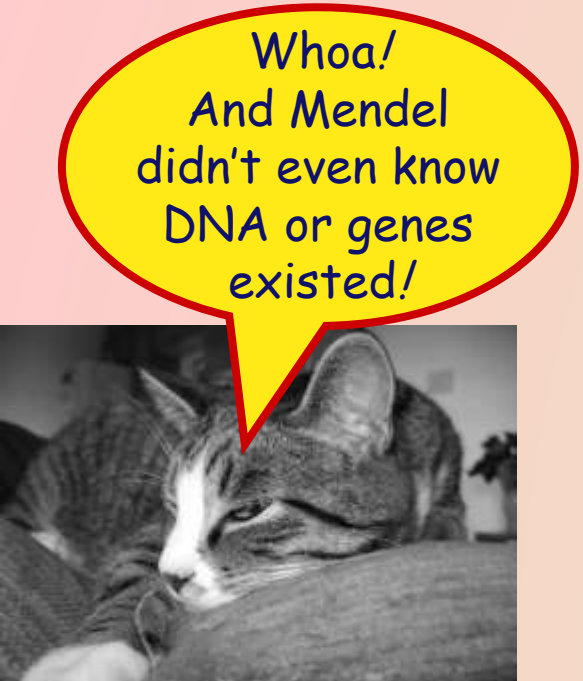


Law of Segregation

- Which stage of meiosis creates the law of segregation?

Metaphase 1



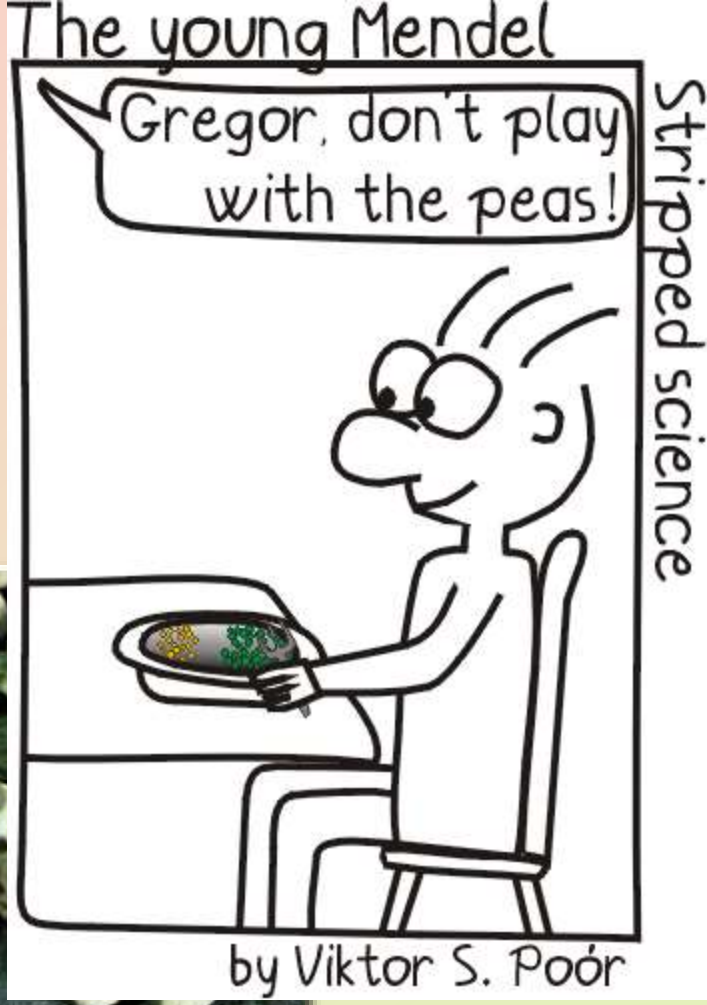


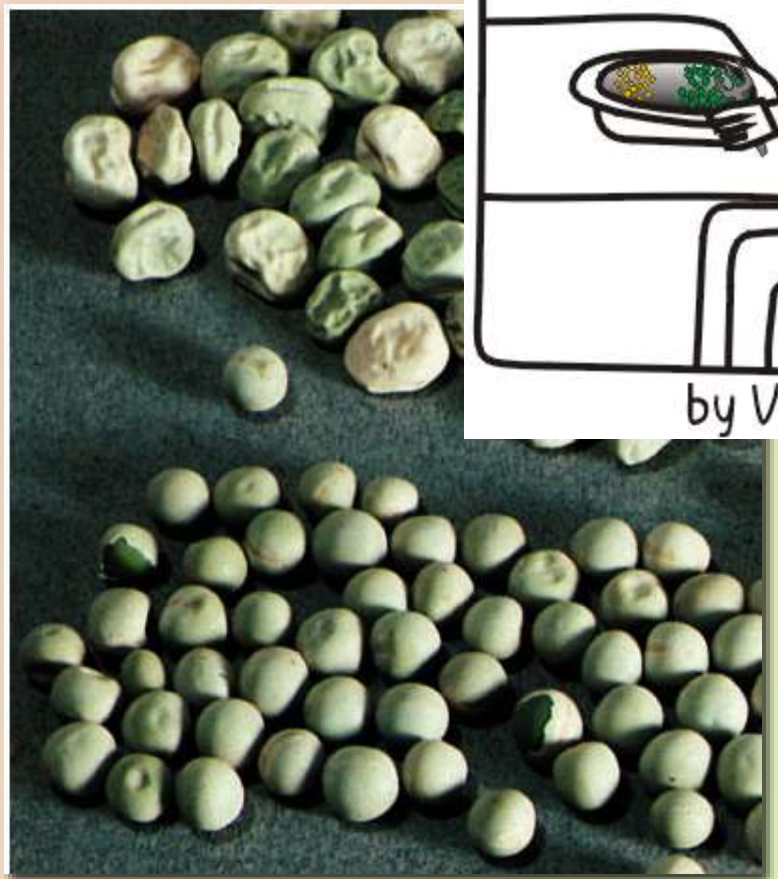
Monohybrid cross

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

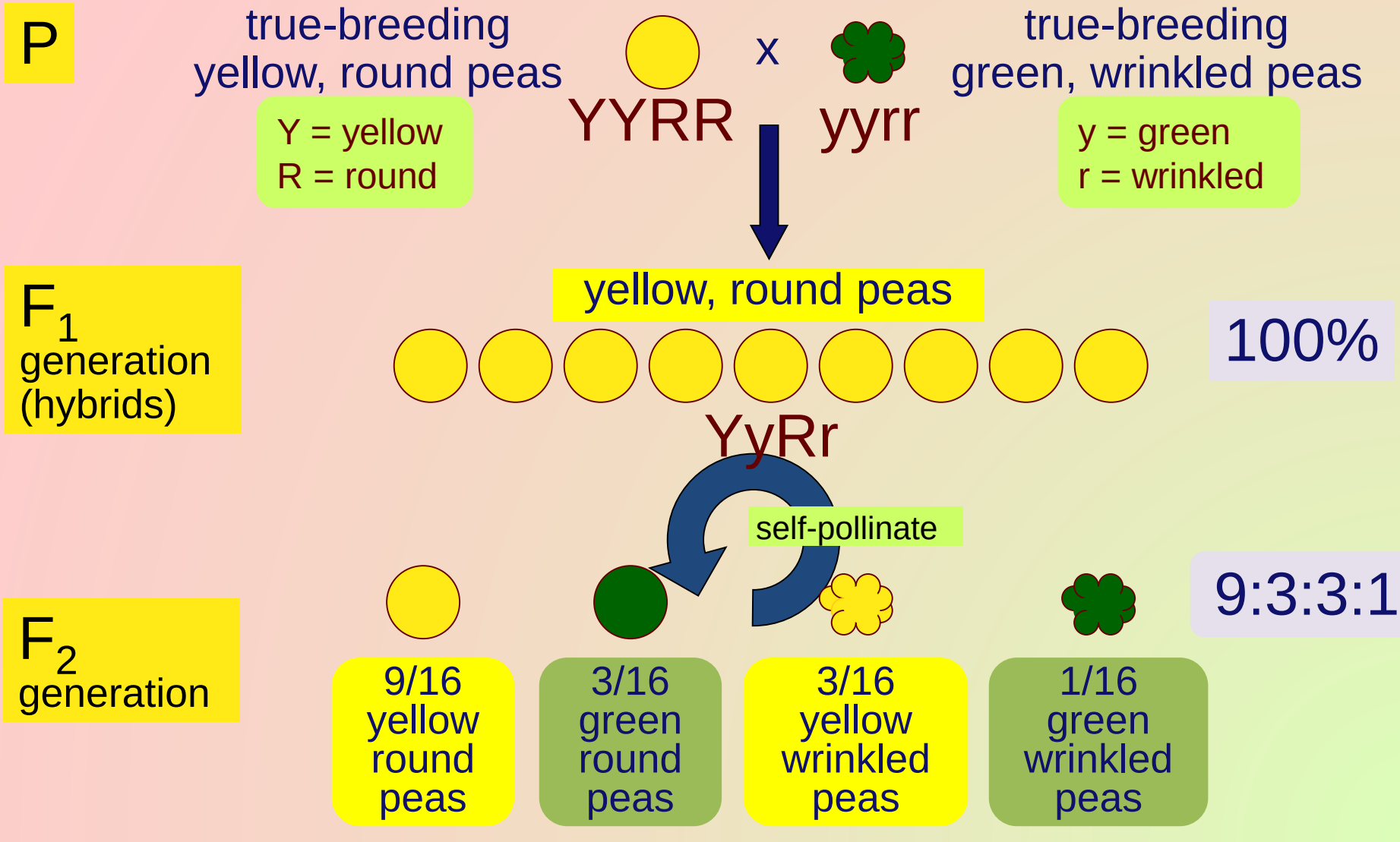
Dihybrid cross

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



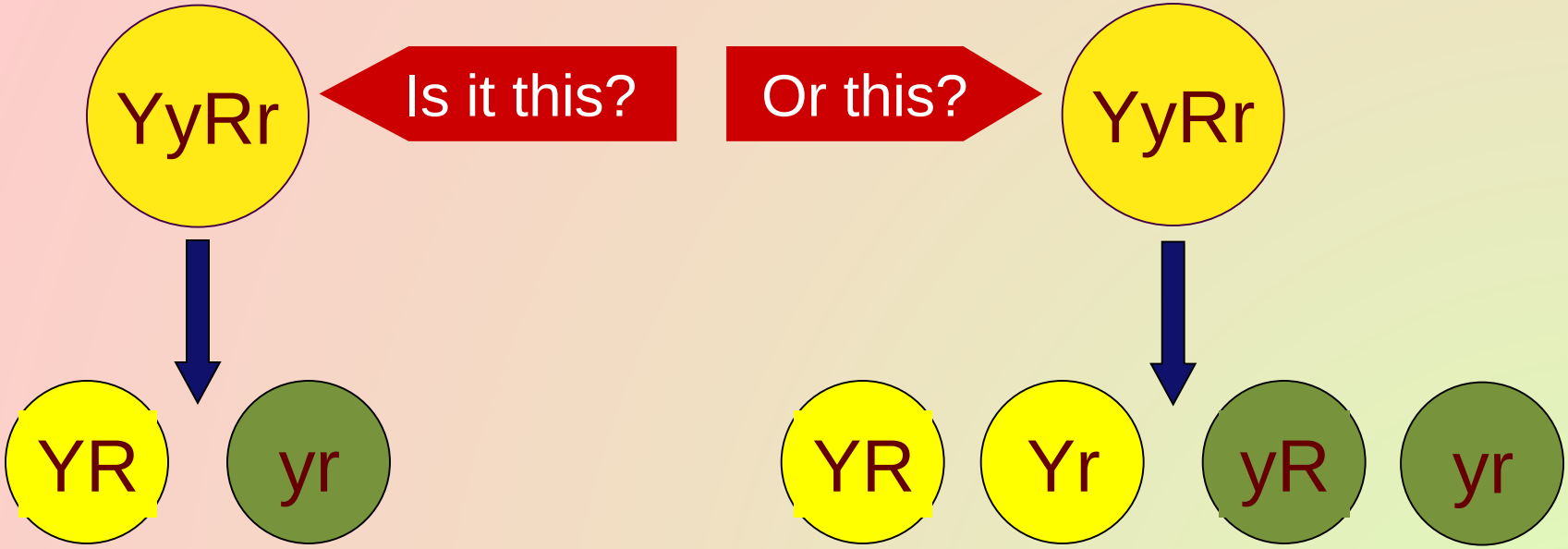


Dihybrid cross

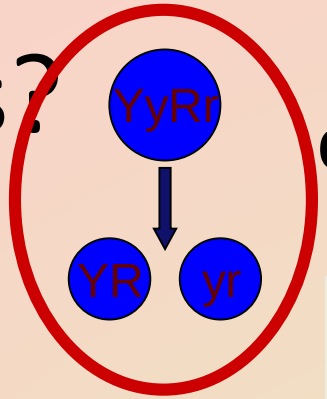


What's going on here?

- If genes are on different chromosomes…
  - how do they assort in the gametes?
  - together or independently?



Is this the way it works?



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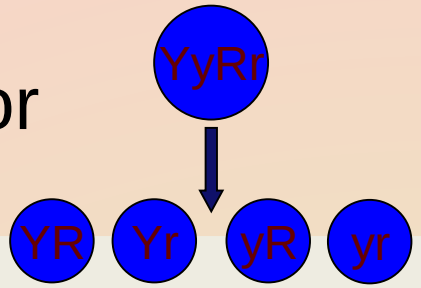
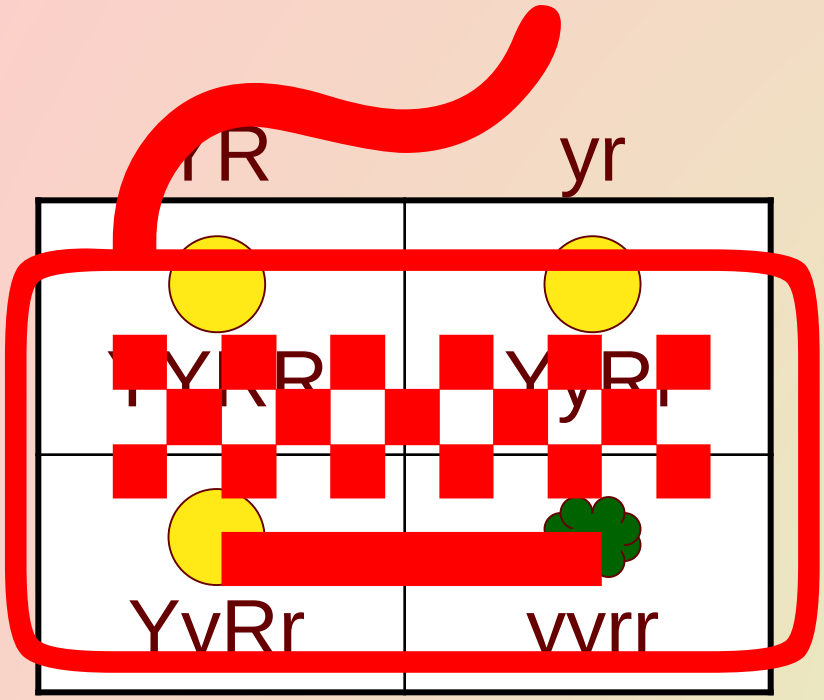


YyRr x YyRr



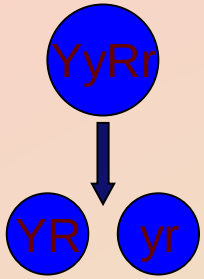
9/16 yellow round

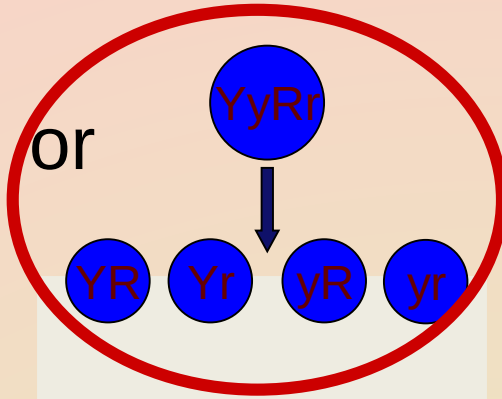
3/16 green round

3/16 yellow wrinkled

1/16 green wrinkled

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

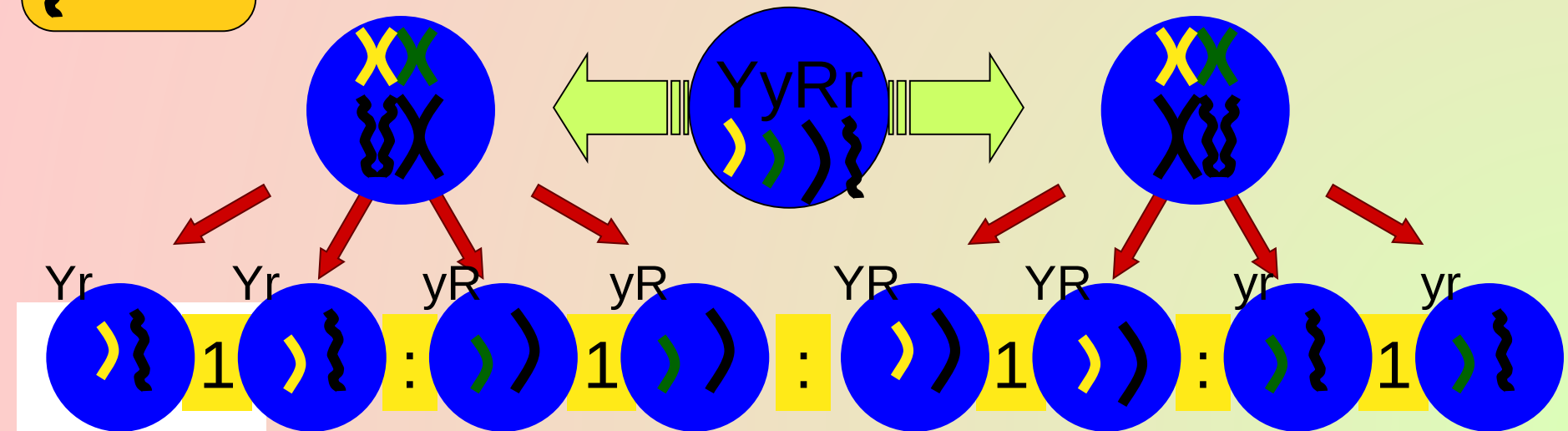
1/16 green wrinkled

Mendel's 2nd law of heredity

- Law of independent assortment
  - different loci (genes) separate into gametes independently
    - non-homologous chromosomes align independently
    - classes of gametes produced in equal amounts
      - YR = Yr = yR = yr
    - only true for genes on separate chromosomes or on same chromosome but so far apart that crossing over happens frequently

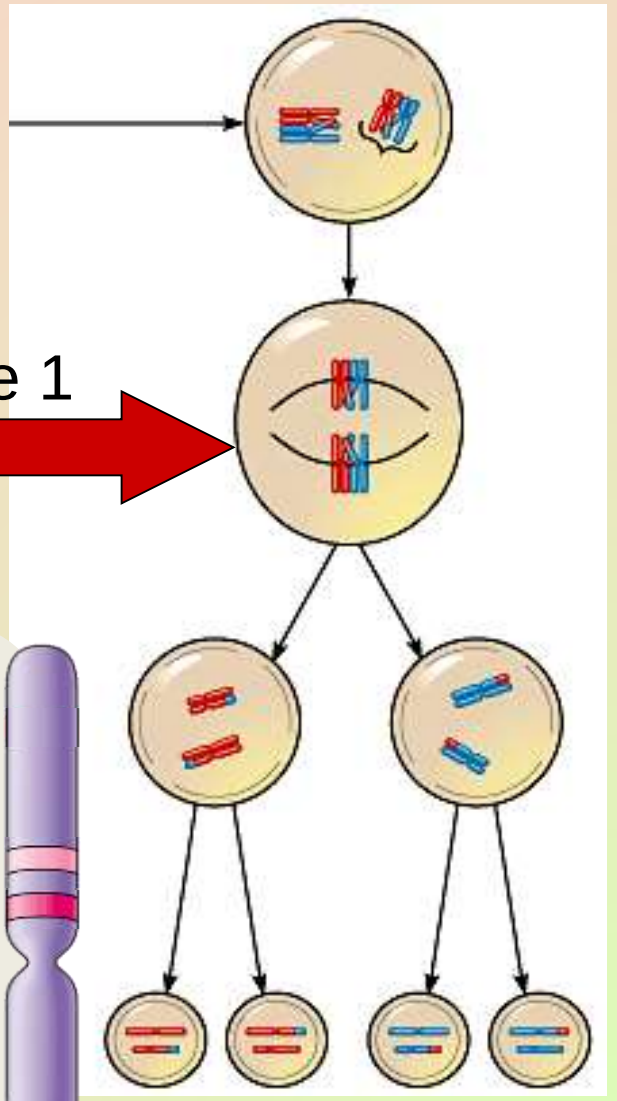
yellow
green

round
wrinkled



Law of Independent Assortment

- Which stage of meiosis creates the law of <u>independent assortment</u>?

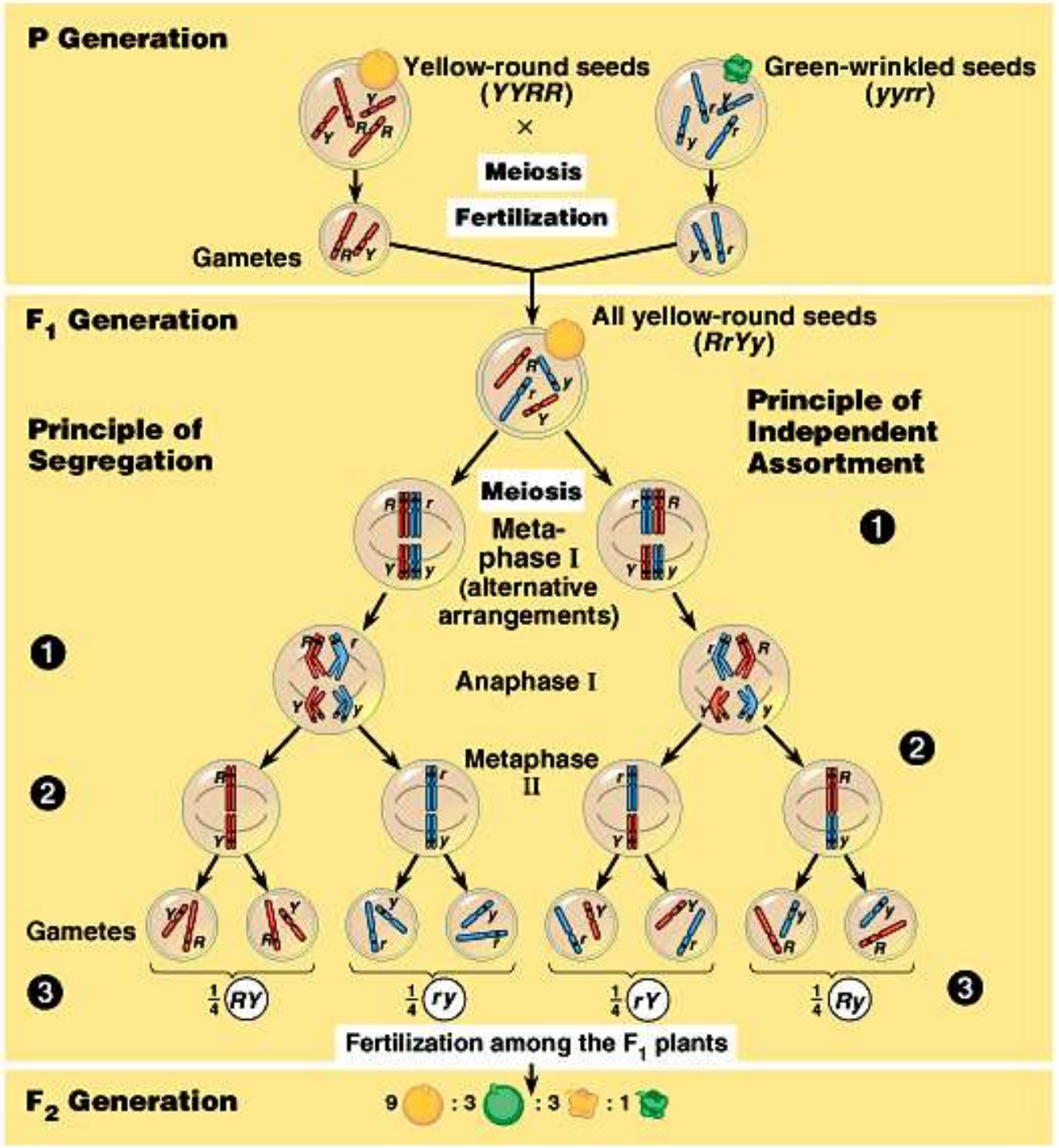


EXCEPTION

- If genes are on same chromosome & close together
  - will usually be inherited together
  - rarely crossover separately
  - "<u>linked</u>"

The chromosomal basis of Mendel's laws…

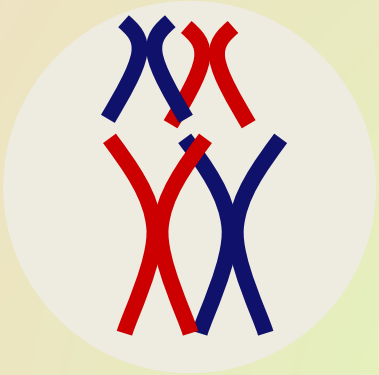
Trace the genetic events through meiosis, gamete formation & fertilization to offspring



Review: Mendel's laws of heredity

- Law of segregation
  - each allele segregates into separate gametes
    - Metaphase 1
- Law of independent assortment
  - genes on separate chromosomes assort into gametes independently
    - Metaphase 1

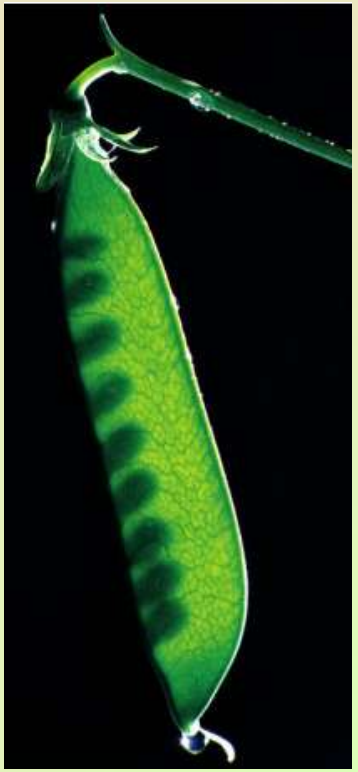
EXCEPTION
- linked genes



metaphase1

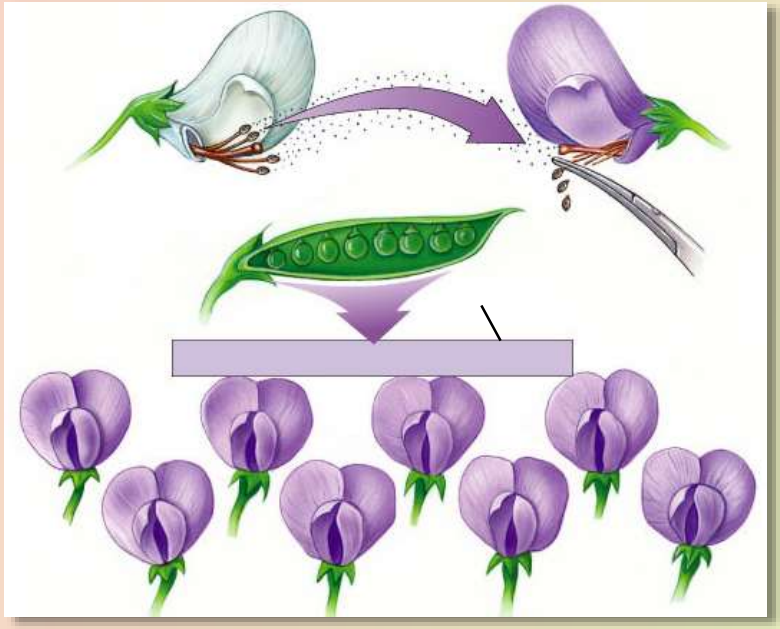
Mendel chose peas wisely

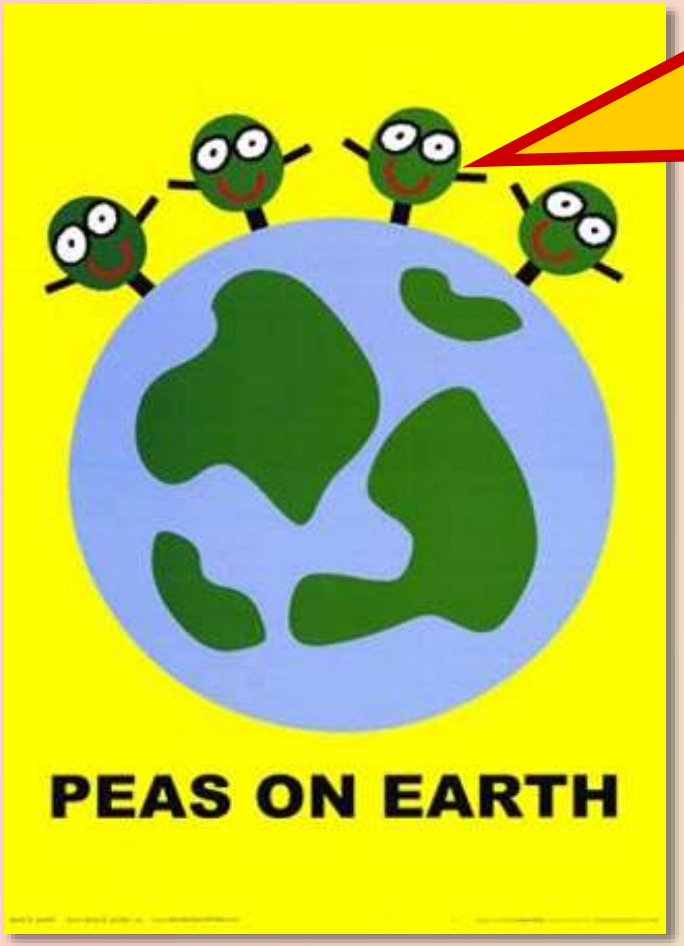
- Pea plants are good for genetic research
  - available in many varieties with distinct heritable features with different variations
    - flower color, seed color, seed shape, etc.
  - Mendel had strict control over which plants mated with which
    - each pea plant has male & female structures
    - 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 with each gene having only 2 alleles,
      - one completely dominant over the other





Any Questions??

Bozeman Biology Ch 14-A

Chapter 9a:

Mendelian Inheritance