Mendelian Genetics

I. Gregor Johann Mendel

(1822-1884)

- Austrian monk
- Studied the inheritance of traits in pea plants
- Developed the laws of inheritance
- Mendel's work was ignored until the turn of the 20th century

- He found that the plants' offspring retained traits of the parents
- Called the "Father of Genetics"

Particulate Inheritance

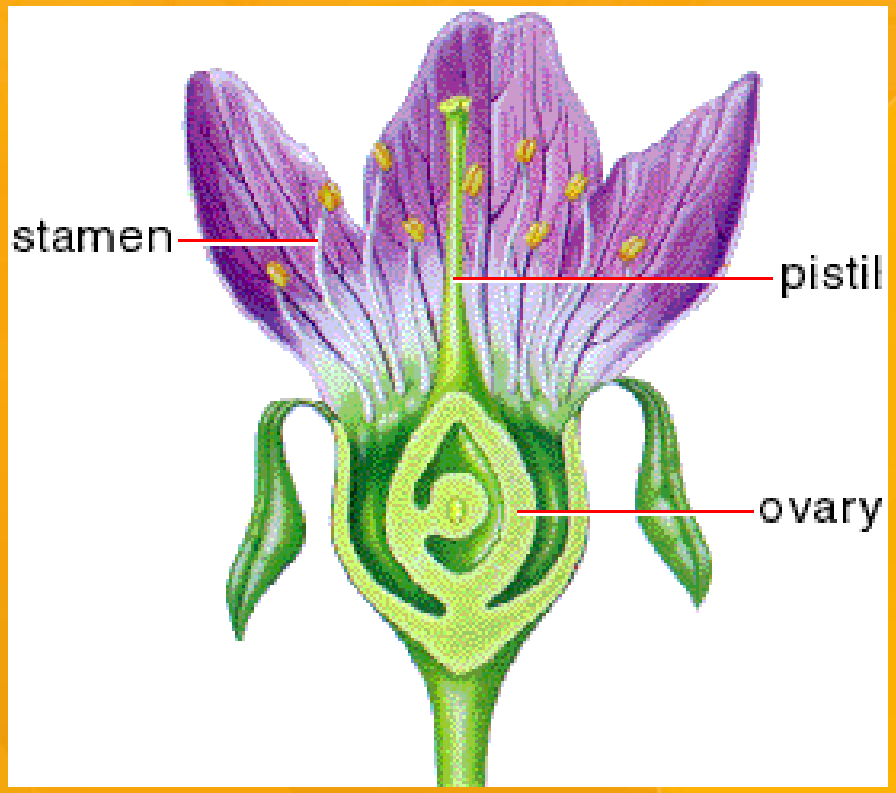
- Mendel stated that physical traits are inherited as "particles" he didn't know that the "particles" were actually Chromosomes & DNA

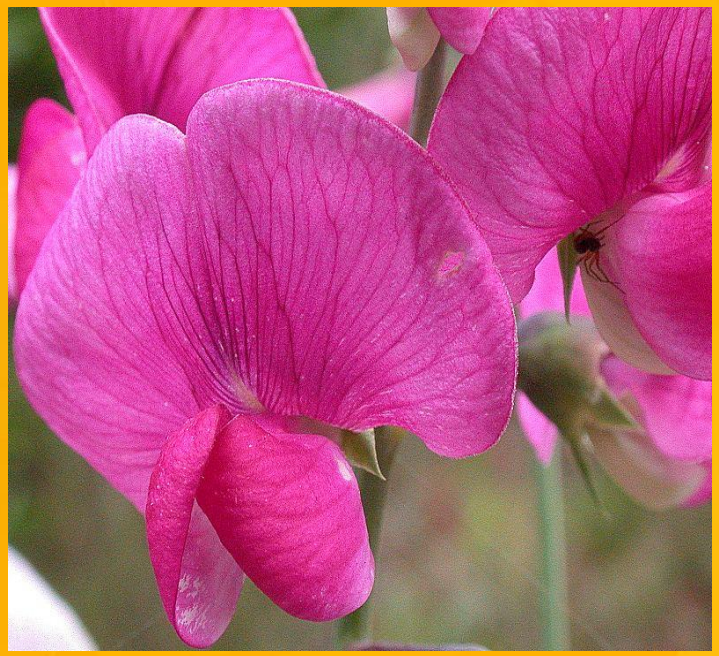
II. Mendel's Pea Plant Experiments

Why peas, *Pisum sativum*?

- Can be grown in a small area
- Produce lots of offspring
- Produce pure plants when allowed to self-pollinate several generations
- Can be artificially cross-pollinated

Reproduction in Flowering Plants





Self-fertilization can occur in the same flower

Cross-fertilization can occur between flowers

Seven Pea Plant Traits Studied by Mendel

Seed shape --- Round (R) or Wrinkled (r)
Seed Color ---- Yellow (Y) or Green (y)
Pod Shape --- Smooth (S) or wrinkled (s)
Pod Color --- Green (G) or Yellow (g)
Flower position---Axial (A) or Terminal (a)
Plant Height --- Tall (T) or Short (t)
Flower color --- Purple (P) or white (p)

Table 11.1 Pea-Plant Characters Studied by Mendel

Character studied	Dominant trait	Recessive trait
Seed shape	smooth 	wrinkled 
Seed color	yellow 	green 
Pod shape	inflated 	wrinkled 
Pod color	green 	yellow 

Flower color	purple 	white 
Flower position	on stem 	at tip 
Stem length	tall 	dwarf 

III. Genetic Terminology

- **Trait** - any characteristic that can be passed from parent to offspring
- **Heredity** - passing of traits from parent to offspring
- **Genetics** - study of heredity

Gene or Trait Terms

- **Alleles** - two forms of a **gene** (dominant & recessive)
- **Dominant** - stronger of two genes, will hide the recessive trait
  - represented by **capital letters (R)**
- **Recessive** - gene that shows up less often in a cross;
  - represented by **lowercase letters (r)**

- **Genotype** - gene combination for a trait (example: RR, Rr, rr)
- **Phenotype** - the physical feature resulting from a genotype (example: red or white)

- **Homozygous (SAME)** - genotype combination involving 2 dominant or 2 recessive genes
  - (example: RR or rr); also called **pure**
- **Heterozygous (DIFFERENT)** genotype combination of one dominant & one recessive allele
  - (example: Rr); also called **hybrid**

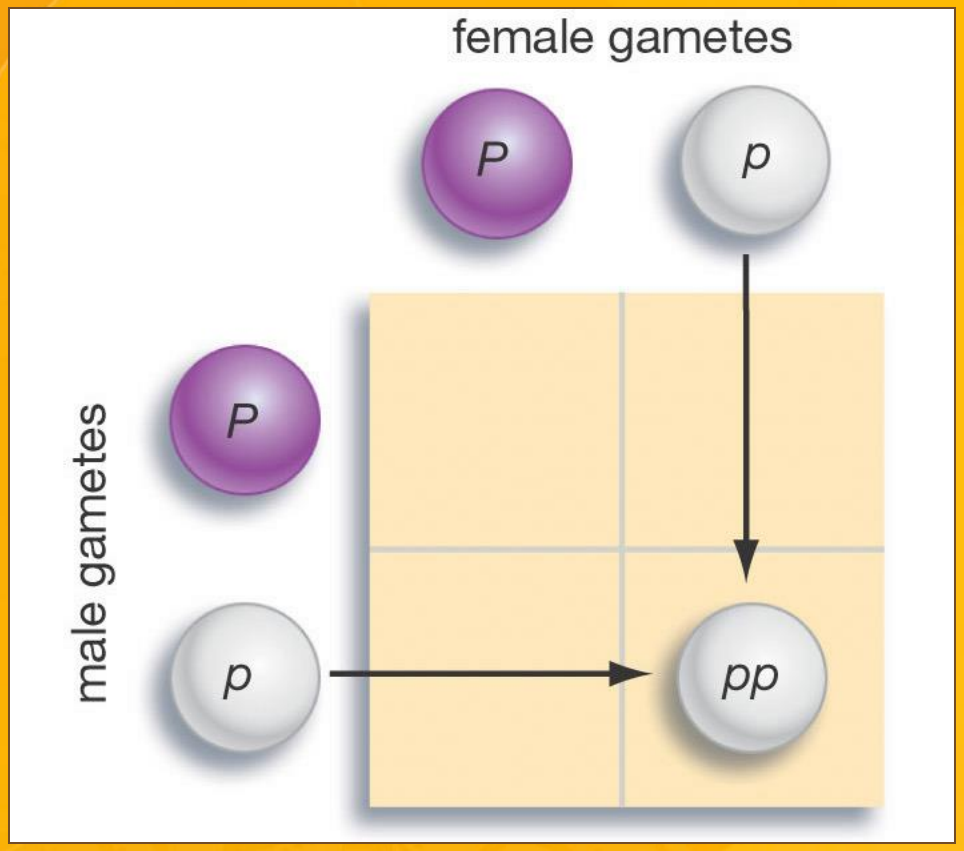
Types of Genetic Crosses

- **Monohybrid cross** - cross involving one trait. example: flower color
- **Dihybrid cross** - cross involving two traits. example: flower color & pea color

IV. Monohybrid Crosses

Punnett Square

Used to help solve genetics problems



How to Make a Punnett Square

Punnett squares allow geneticists to predict the possible genotypes and phenotypes of offspring.

In this example, both parents are heterozygous for yellow-pea allele (*Yy*).

1 Make the grid

Place the alleles of the gametes of one parent along the top of a grid and those of the other parent along the left-hand side.

Parent 1 Yy

Parent 2 Yy

	Y	y
Y		
y		

2 Fill in the grid

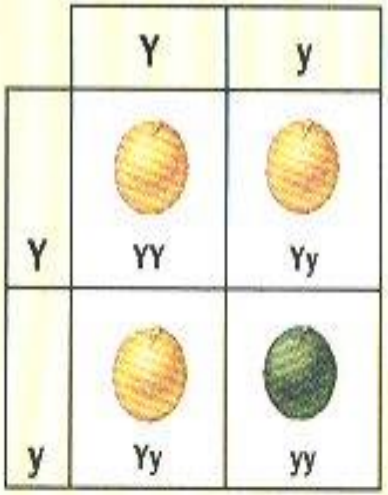
Combine the parent alleles inside the boxes. The letters show the genotypes of the offspring.

	Y	y
Y	YY	Yy
y	Yy	yy

The genotype ratio is 1:2:1, meaning 1 *YY*, 2 *Yy*, 1 *yy*.

3 Fill in the offspring

Use the Law of Dominance to determine the phenotypes and phenotype ratio of the offspring.



The phenotype ratio is 3:1, meaning 3 yellow peas to 1 green pea.

Monohybrid Cross

Trait: Seed Shape

Alleles: R – Round r – Wrinkled

Cross: Round seeds x Wrinkled seeds

RR x rr

	r	r
R	Rr	Rr
R	Rr	Rr

Genotype: Rr

Phenotype: Round

Genotypic Ratio: All alike 100%

Phenotypic Ratio: All alike 100%

Monohybrid Cross

Trait: Seed Shape

Alleles: R – Round r – Wrinkled

Cross: Round seeds x Round seeds

Rr x Rr

	R	r
R	RR	Rr
r	Rr	rr

Genotype: RR, Rr, rr

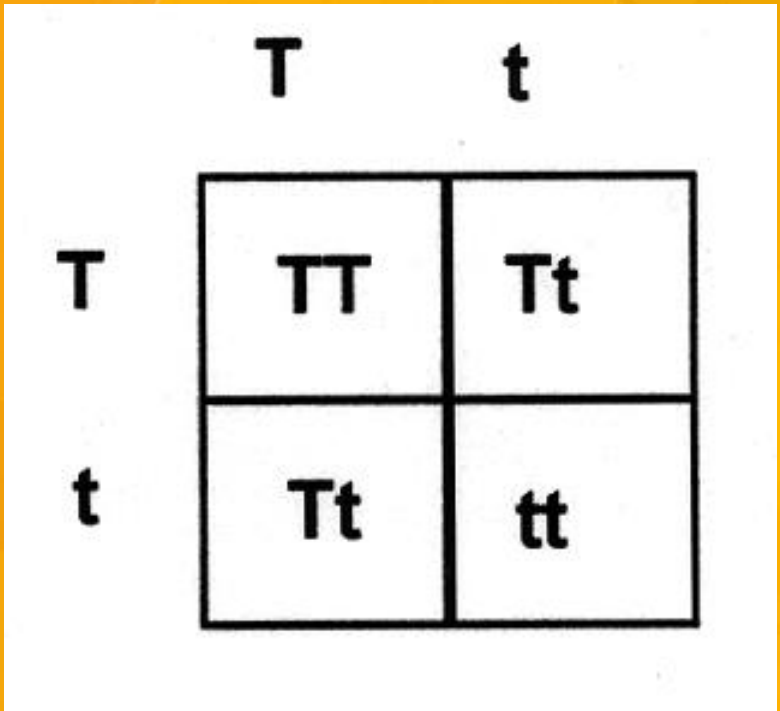
Phenotype: Round & wrinkled

G.Ratio: 1:2:1

P.Ratio: 3:1

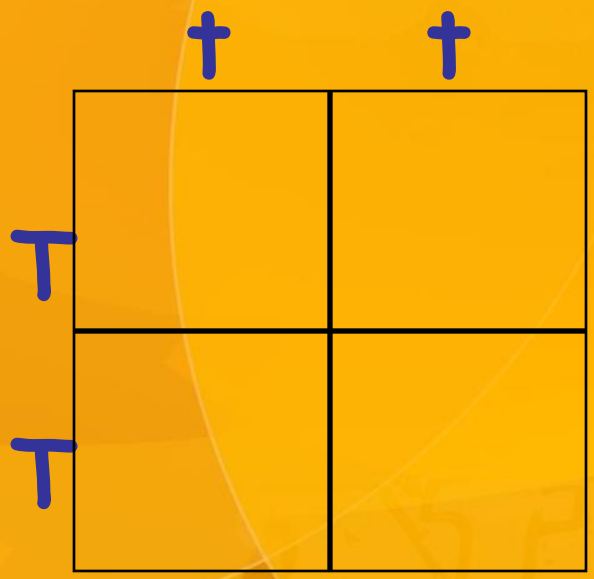
What Do the Peas Look Like?

Genetic Practice Problems



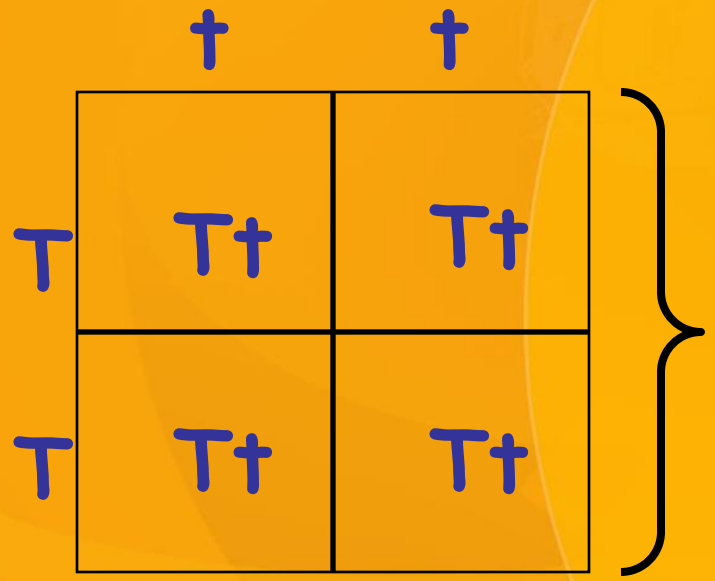
Cross

tall (TT) x dwarf (tt) pea plants



Solution:

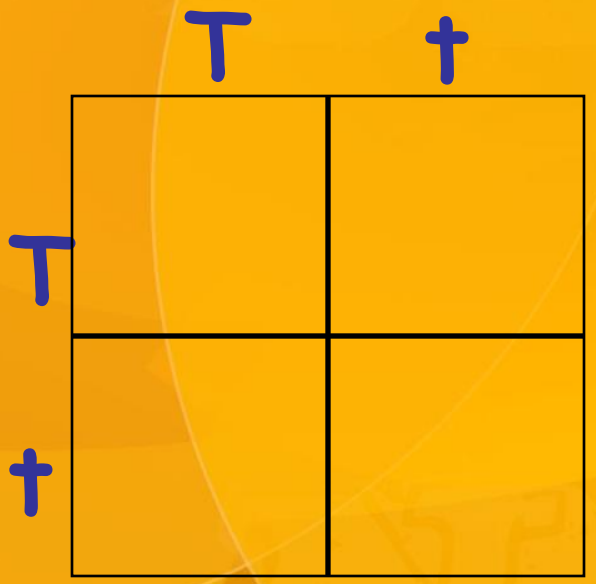
tall (TT) vs. dwarf (tt) pea plants



All Tt = tall
(heterozygous tall)

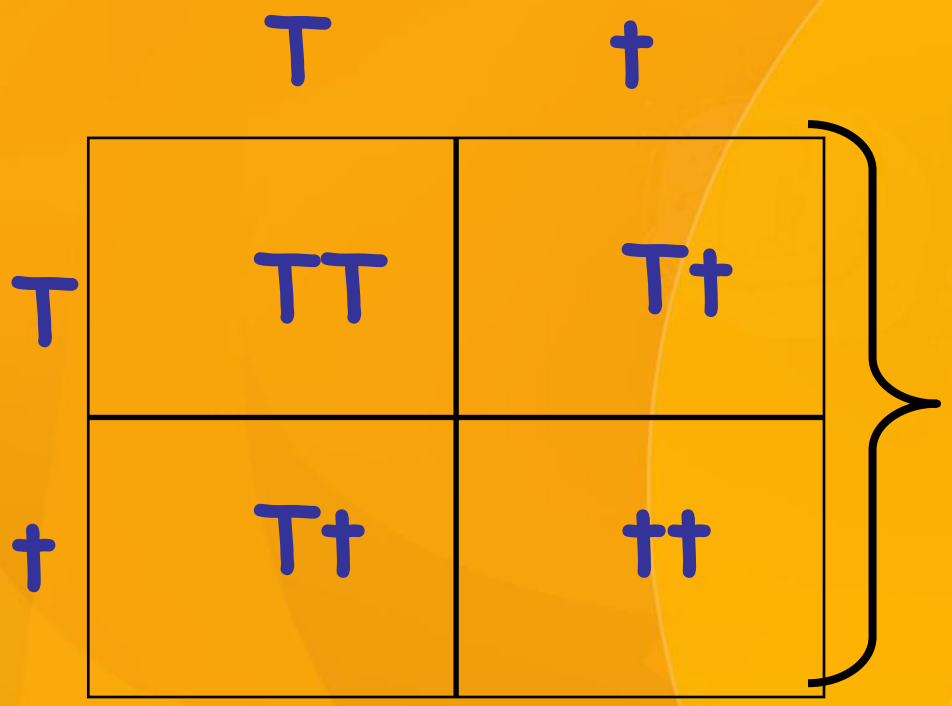
Cross

tall (Tt) vs. tall (Tt) pea plants



Solution:

tall (Tt) x tall (Tt) pea plants



1/4 (25%) = TT
1/2 (50%) = Tt
1/4 (25%) = tt

1:2:1 genotype
3:1 phenotype

V. Mendel's Laws

A. Law of Dominance

In a cross of parents that are pure for different traits (round or smooth), only one form of the trait will appear in the next generation.

All the offspring will be heterozygous and express only the dominant trait.

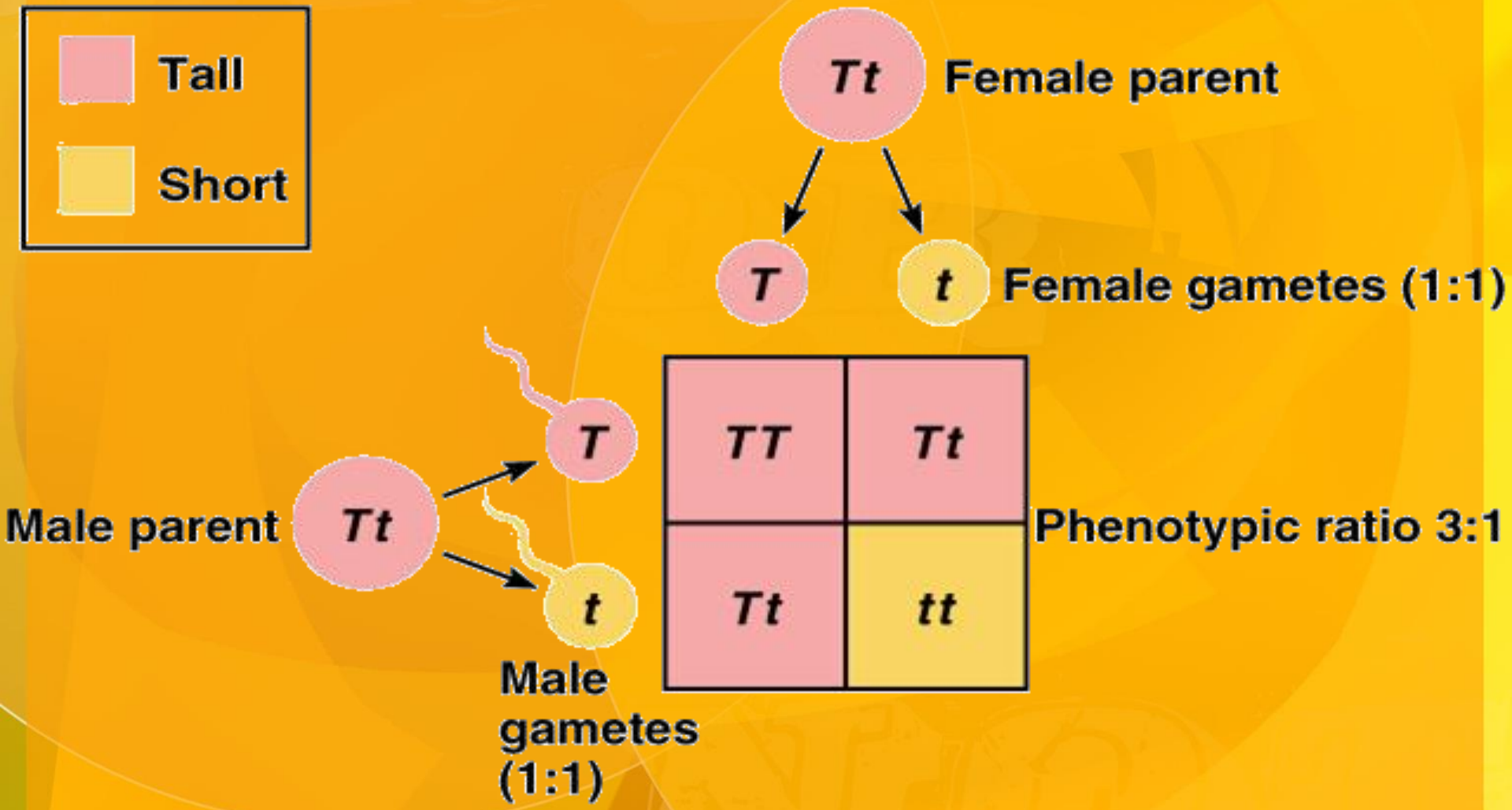
RR x rr yields all Rr (round seeds)

B. Law of Segregation

During the formation of gametes (eggs or sperm), the two alleles responsible for a trait separate from each other.

Alleles for a trait are then "recombined" at fertilization, producing the genotype for the traits of the offspring.

Applying the Law of Segregation



C. Law of Independent Assortment

- Alleles for *different* traits are distributed to sex cells (& offspring) independently of one another.
- This law can be illustrated using *dihybrid crosses*.

Dihybrid Cross

Traits: Seed shape & Seed color

Alleles: R round Y yellow
r wrinkled y green

Parents

RrYy x RrYy

RY Ry rY ry

RY Ry rY ry

All possible gamete combinations

Dihybrid Cross

	RY	Ry	rY	ry
RY				
Ry				
rY				
ry				

Dihybrid Cross

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Round/Yellow: 9

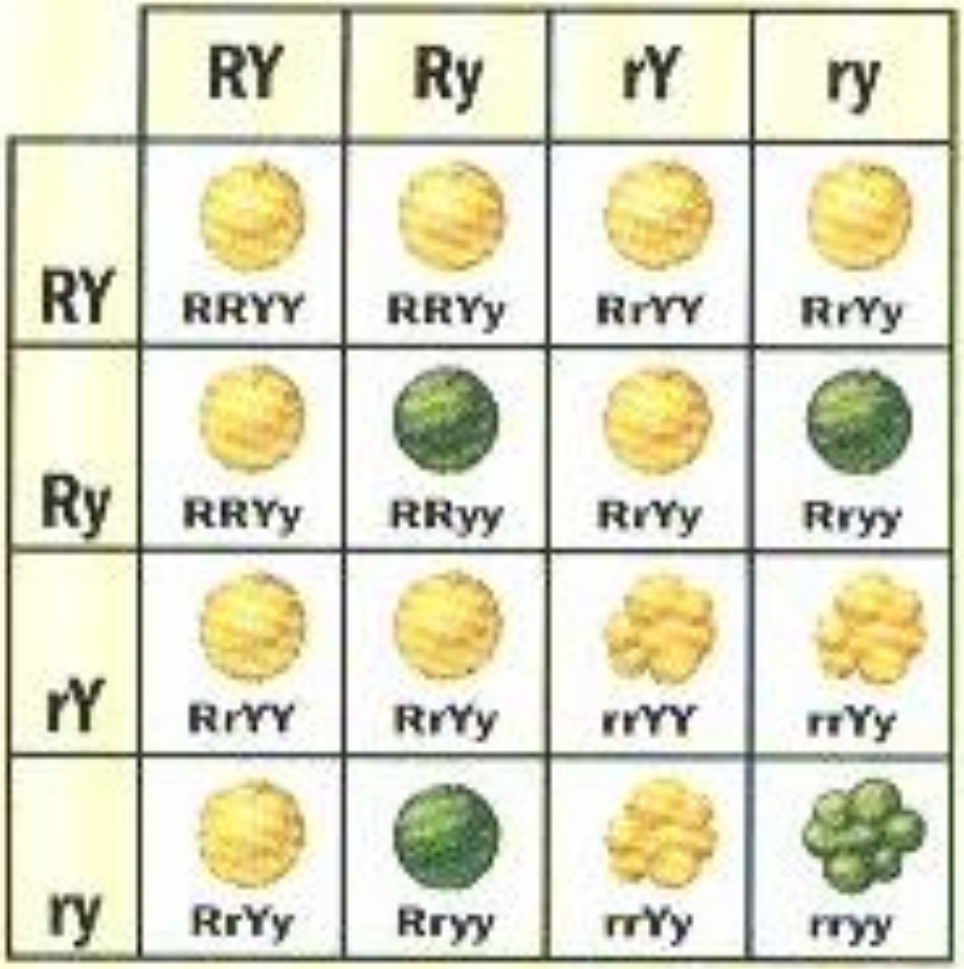
Round/green: 3

wrinkled/Yellow: 3

wrinkled/green: 1

9:3:3:1 phenotypic ratio

Dihybrid Cross



Round/Yellow: 9
Round/green: 3
wrinkled/Yellow: 3
wrinkled/green: 1

9:3:3:1

VI. Other Genetic Information

A. Incomplete Dominance

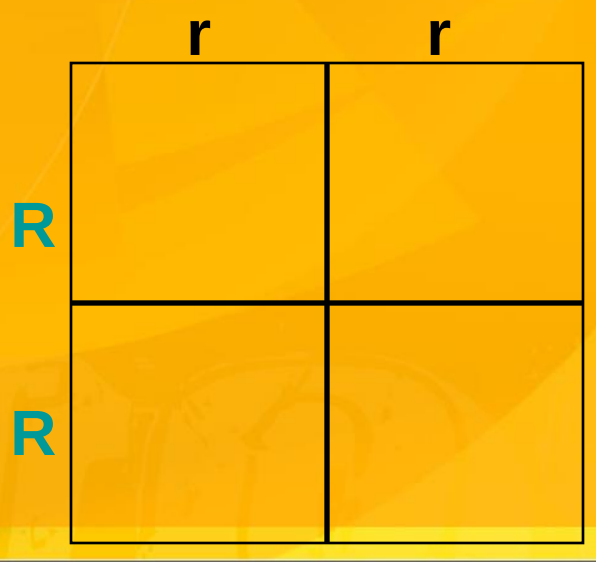
Hybrids (Rr) have an appearance **in between** the **phenotypes** of the two parental varieties.

Example: snapdragons (flower)

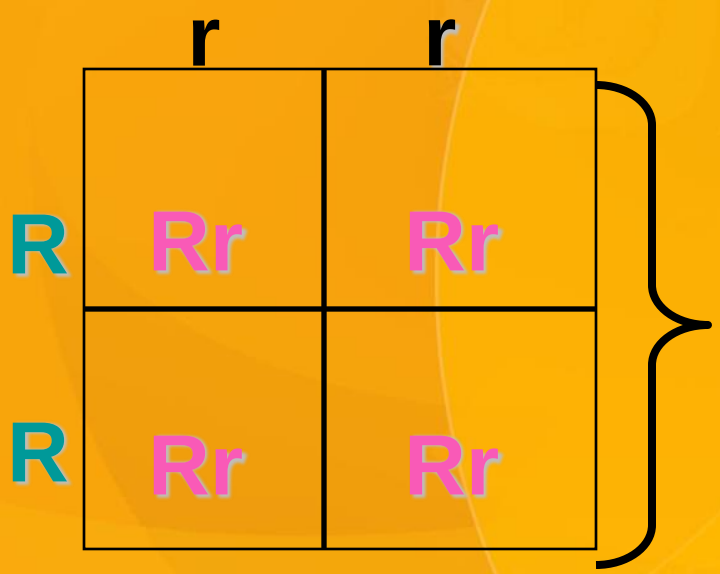
red (RR) x white (rr)

RR = red flower

rr = white flower



Incomplete Dominance



All Rr = pink
(heterozygous pink)

B. Codominance

Two alleles are expressed (multiple alleles) in heterozygous individuals.

Example: blood type

1. type A = I^AI^A or I^Ai

2. type B = I^BI^B or I^Bi

3. type AB = I^AI^B

4. type O = ii

Codominance Problem

Example: homozygous male Type B (I^BI^B)

x

heterozygous female Type A (I^Ai)

	I^A	i
I^B	I^AI^B	I^Bi
I^B	I^AI^B	I^Bi

1/2 = I^AI^B

1/2 = I^Bi

Another Codominance Problem

- **Example:** male Type O (ii)
  ×
  female type AB (I^AI^B)

	I^A	I^B
i	I^Ai	I^Bi
i	I^Ai	I^Bi

1/2 = I^Ai

1/2 = I^Bi

C. Sex-linked Traits

Traits (genes) located on the sex chromosomes

Sex chromosomes are X and Y

XX genotype for females

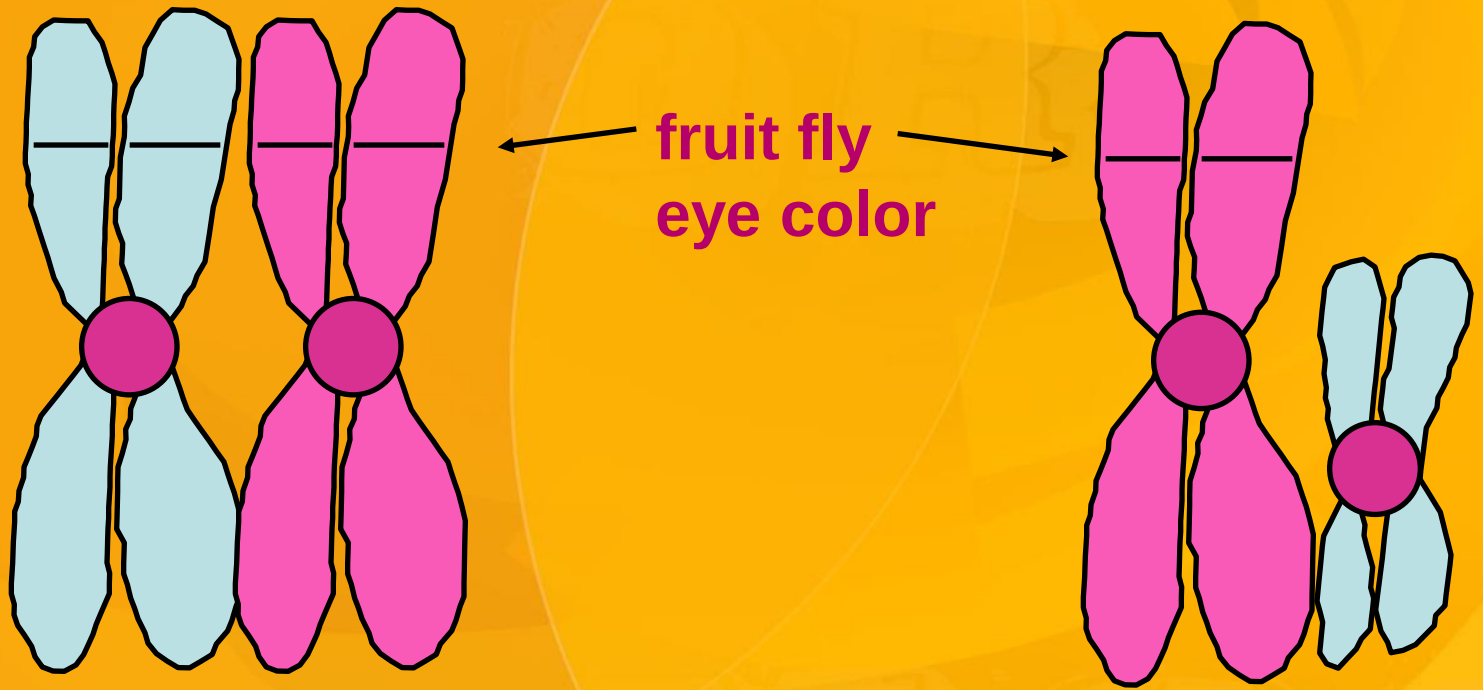
XY genotype for males

Many sex-linked traits carried on X chromosome

Sex-linked Traits

Example: Eye color in fruit flies

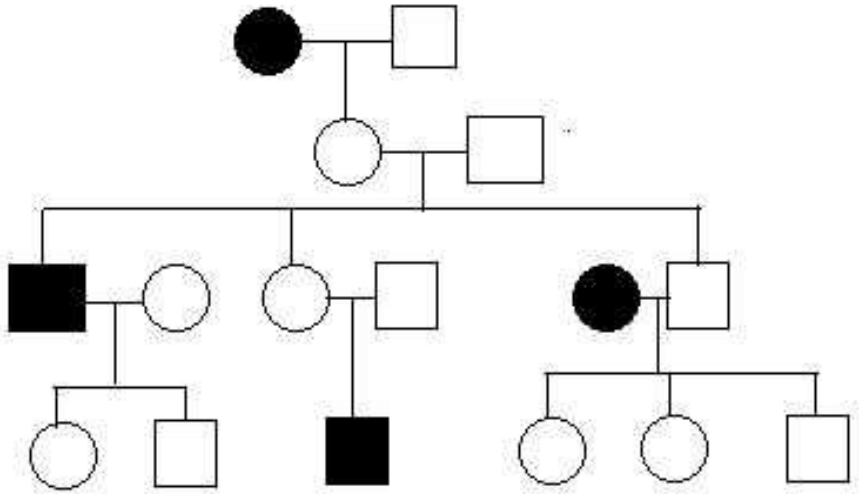
Sex Chromosomes



XX chromosome - female

Xy chromosome - male

D. Pedigree Chart

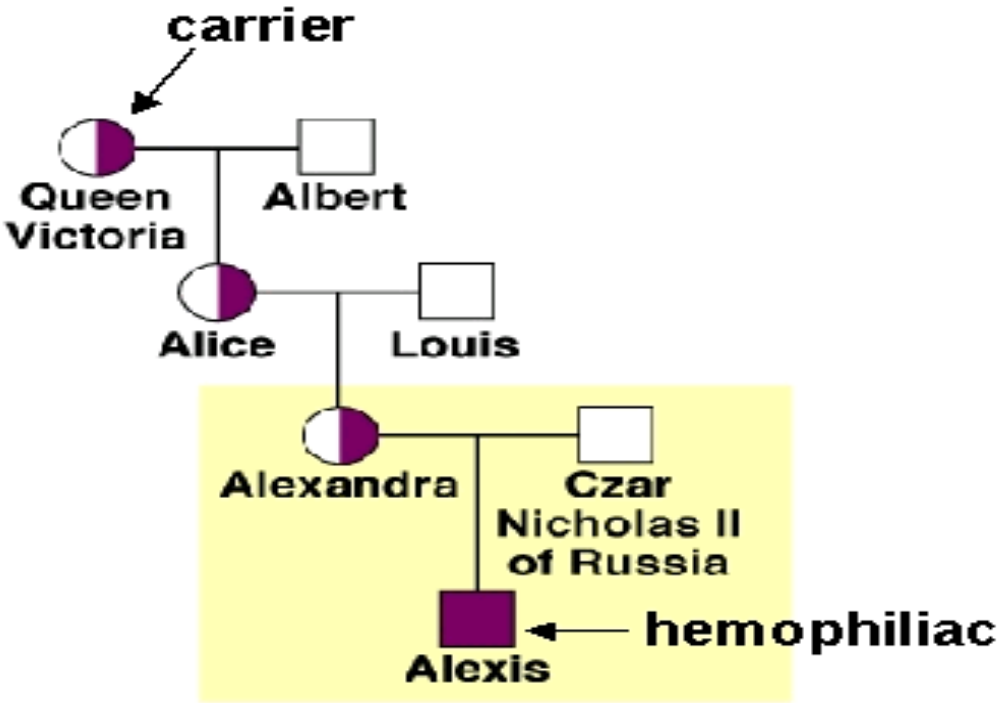


= male

= female

Female Carriers

In a sex-linked trait (like hemophilia), women are carriers, and men have the phenotype more often.



Genetic Disorders

Hemophilia

- blood does not clot

-Queen Victoria

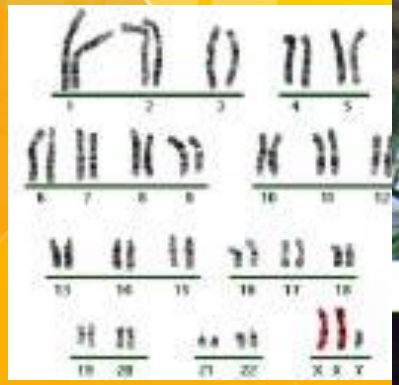
Sickle cell Anemia

- predominantly African Americans
- Results in abnormally shaped red blood cells

Down Syndrome

- Extra chromosome in 21st pair (trisomy)
- Mild to severe disabilities
- More common in pregnant women over 40-45
- Short, stocky, almond shaped eyes, thick tongue and prone to heart defects

- Klinefelter's syndrome
  - Extra sex chromosome (trisomy)
  - Males (XXY)
  - Under developed testes, sterile and feminine
- Turner syndrome
  - 1 less chromosome (monosomy)
  - Females (XO)
  - Normal childhood but then do not develop sexually, sterile



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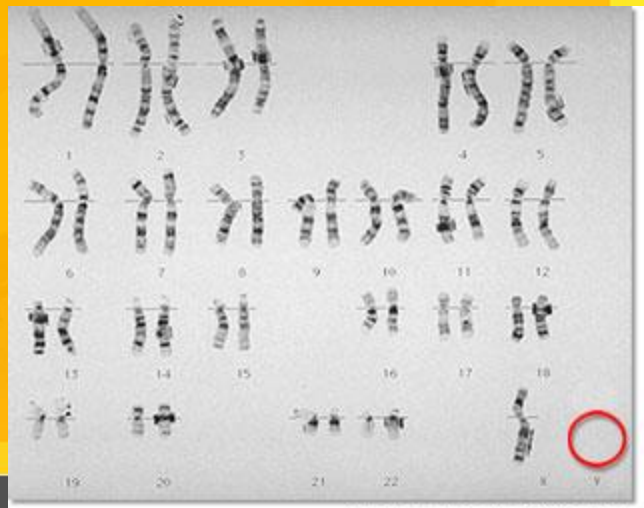

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Dyslexia – letters and numbers are backwards