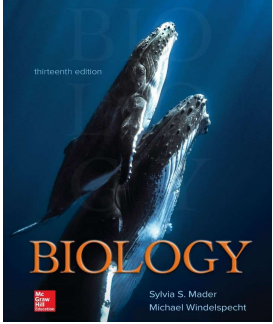


# Mendelian Inheritance



thirteenth edition

**BIOLOGY**

Sylvia S. Mader  
Michael Windelspecht

**Biology**

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Michael Windelspecht

Chapter 11  
Mendelian Patterns of Inheritance  
Lecture Outline

See separate FlexArt PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

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## Outline

- 11.1 Gregor Mendel
- 11.2 Mendel's Laws
- 11.3 Mendelian Patterns of Inheritance and Human Disease
- 11.4 Beyond Mendelian Inheritance

11-2

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## Garden Pea Anatomy (2)

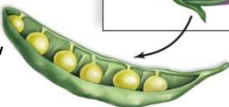


Cutting away anthers



Brushing on pollen from another plant

All peas are yellow when one parent produces yellow seeds and the other parent produces green seeds.



[Jump to Garden Pea Anatomy \(2\) Long Description](#)

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# Mendelian Inheritance

## 11.2 Mendel's Laws

Mendel performed cross-breeding experiments.

- Used “true-breeding” (homozygous) plants
- Chose varieties that differed in only one trait (**monohybrid cross**)
- Performed reciprocal crosses
  - Parental generation = P
  - First filial generation offspring =  $F_1$
  - Second filial generation offspring =  $F_2$
- Formulated the **law of segregation**

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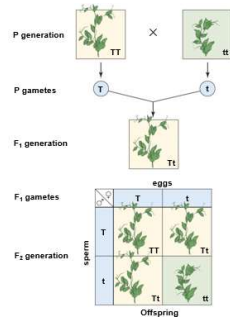
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## Monohybrid Cross Done by Mendel (4)



Allele Key  
T = tall plant  
t = short plant

Phenotypic Ratio  
3 tall  
1 short

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[Jump to Monohybrid Cross Done by Mendel \(4\) Long Description](#)

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## Mendel's Laws (1)

Law of Segregation:

- Each individual has a pair of factors (alleles) for each trait.
- The factors (alleles) segregate (separate) during gamete (sperm and egg) formation.
- Each gamete contains only one factor (allele) from each pair of factors.
- Fertilization gives the offspring two factors for each trait.
- Results of the monohybrid cross: All  $F_1$  plants were tall, disproving blending hypothesis.

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# Mendelian Inheritance

## Mendel's Laws (2)

Classical Genetics and Mendel's Cross:

- Each trait in a pea plant is controlled by two alleles (alternate forms of a gene).
- **Dominant allele** (capital letter) masks the expression of the **recessive allele** (lowercase).
- Alleles occur on a homologous pair of chromosomes at a particular gene locus.
  - **Homozygous** = identical alleles
  - **Heterozygous** = different alleles

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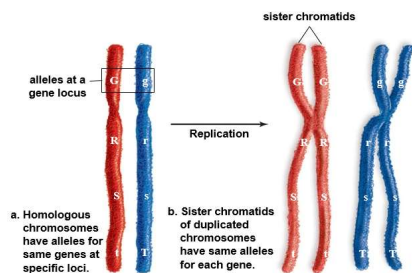
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## Homologous Chromosomes



[Jump to Homologous Chromosomes Long Description](#)

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## Relationship Between Observed Phenotype and F<sub>2</sub> Offspring

Trait	Dominant	Characteristics		F <sub>2</sub> Results		
			Recessive	Dominant	Recessive	Ratio
Stem length	Tall		Short	787	277	2.84:1
Pod shape	Inflated		Constricted	882	299	2.95:1
Seed shape	Round		Wrinkled	5,474	1,850	2.96:1
Seed color	Yellow		Green	6,022	2,001	3.01:1
Flower position	Axial		Terminal	651	207	3.14:1
Flower color	Purple		White	705	224	3.15:1
Pod color	Green		Yellow	428	152	2.82:1
Totals:				14,549	5,010	2.98:1

[Jump to Relationship Between Observed Phenotype and F<sub>2</sub> Offspring Long Description](#)

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# Mendelian Inheritance

## Mendel's Laws (3)

### Genotype

- It refers to the two alleles an individual has for a specific trait.
- If identical, genotype is homozygous.
- If different, genotype is heterozygous.

### Phenotype

- It refers to the physical appearance of the individual.

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## Mendel's Cross Viewed by Modern Genetics

The dominant and recessive alleles represent DNA sequences that code for proteins.

The dominant allele codes for the protein associated with the normal gene function within the cell.

The recessive allele represents a "loss of function."

During meiosis I, the homologous chromosomes separate.

- The two alleles separate from each other.
- The process of meiosis explains Mendel's law of segregation and why only one allele for each trait is in a gamete.

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## Mendel's Laws (4)

A **dihybrid cross** uses true-breeding plants differing in two traits.

Mendel tracked each trait through two generations.

- It started with true-breeding plants differing in two traits.
- The  $F_1$  plants showed both dominant characteristics.
- $F_1$  plants self-pollinated.
- He observed phenotypes among  $F_2$  plants.

Mendel formulated the **law of independent assortment**.

- The pair of factors for one trait segregate independently of the factors for other traits.
- All possible combinations of factors can occur in the gametes.

P generation is the parental generation in a breeding experiment.

$F_1$  generation is the first-generation offspring in a breeding experiment.

$F_2$  generation is the second-generation offspring in a breeding experiment.

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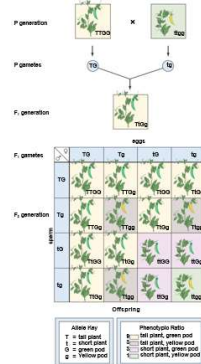
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# Mendelian Inheritance

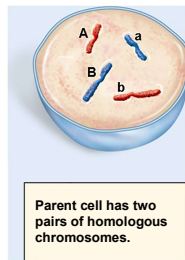
## Dihybrid Cross Done by Mendel



[Jump to Dihybrid Cross Done by Mendel Long Description](#)

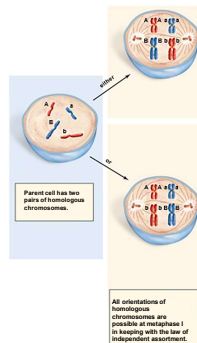
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## Independent Assortment and Segregation during Meiosis (1)



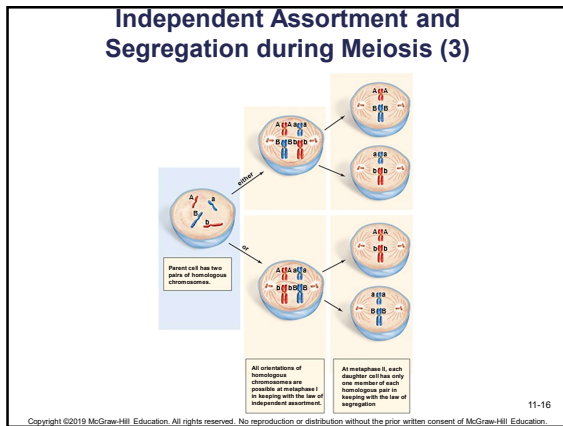
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## Independent Assortment and Segregation during Meiosis (2)



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# Mendelian Inheritance




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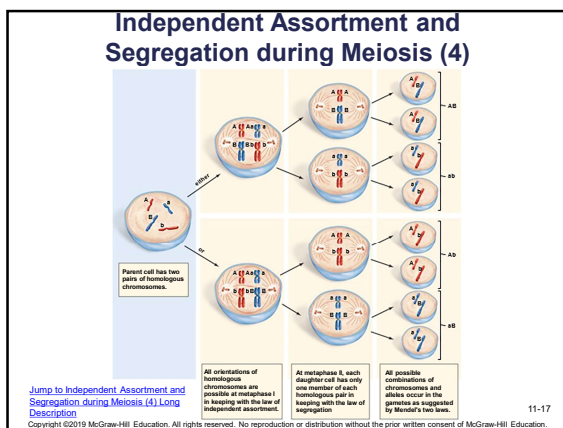
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## Mendel's Laws (5)

### Punnett Square

- Table listing all possible genotypes resulting from a cross
- All possible sperm genotypes are lined up on one side.
- All possible egg genotypes are lined up on the other side.
- All possible zygote genotypes are placed within the squares.

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# Mendelian Inheritance

## Mendel and the Laws of Probability (1)

### Punnett Square

- It allows us to easily calculate probability of genotypes and phenotypes among the offspring.
- The Punnett square in the next slide shows a 50% (or  $\frac{1}{2}$ ) chance.
  - The chance of  $E = \frac{1}{2}$
  - The chance of  $e = \frac{1}{2}$
- An offspring will inherit:
  - The chance of  $EE = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
  - The chance of  $Ee = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
  - The chance of  $eE = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
  - The chance of  $ee = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
- The sum rule allows us to add the genotypes that produce the identical phenotype to find out the chance of a particular phenotype.

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## Mendel and the Laws of Probability (2)

### Punnett Square

- It allows us to easily calculate probability of genotypes and phenotypes among the offspring.
- Punnett square in next slide shows a 50% (or  $\frac{1}{2}$ ) chance.
- The chance of  $A = \frac{1}{2}$
- The chance of  $a = \frac{1}{2}$

### An offspring will inherit

- The chance of  $AA = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
- The chance of  $Aa = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
- The chance of  $aA = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
- The chance of  $aa = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

The sum rule allows us to add the genotypes that produce the identical phenotype to find out the chance of a particular phenotype.

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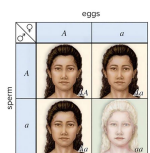
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## Punnett Square

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Offspring

### Allele Key

A = Normal pigmentation  
a = lack of pigmentation

### Phenotypic Ratio

3 normal pigmentation  
1 albino (no pigmentation)

[Jump to Punnett Square Long Description](#)

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# Mendelian Inheritance

## 11.3 Mendelian Patterns of Inheritance and Human Disease

Genetic disorders are medical conditions caused by alleles inherited from parents.

**Autosome** is any chromosome other than a sex chromosome (X or Y).

Genetic disorders caused by genes on autosomes are called autosomal disorders.

- Some genetic disorders are autosomal dominant.
  - An individual with AA has the disorder.
  - An individual with Aa has the disorder.
  - An individual with aa does NOT have the disorder.
- Other genetic disorders are autosomal recessive.
  - An individual with AA does NOT have the disorder.
  - An individual with Aa does NOT have the disorder, but is a carrier.
  - An individual with aa DOES have the disorder.

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## 11.4 Beyond Mendelian Inheritance

Some traits are controlled by **multiple alleles** (multiple allelic traits).

The gene exists in several allelic forms, but each individual only has two alleles.

ABO blood types

- The alleles:
  - antigen on red blood cells, anti-B antibody in plasma
  - antigen on red blood cells, anti-A antibody in plasma
  - $i$  = Neither A nor B antigens on red blood cells, both anti-A and anti-B antibodies in plasma

The ABO blood type is also an example of **codominance**.

- More than one allele is fully expressed.
- Both are expressed in the presence of the other.

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## ABO Blood Type

Phenotype	Genotype
A	$I^A I^A, I^A i$
B	$I^B I^B, I^B i$
AB	$I^A I^B$
O	$ii$

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# Mendelian Inheritance

## Beyond Mendelian Inheritance (1)

### Incomplete Dominance

- Heterozygote has a phenotype intermediate between that of either homozygote.
- Homozygous red has red phenotype.
- Homozygous white has white phenotype.
- Heterozygote has pink (intermediate) phenotype.
- Phenotype reveals genotype without a testcross.

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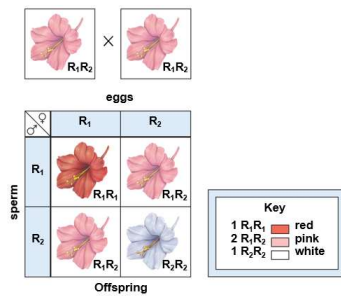
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## Incomplete Dominance



[Jump to Incomplete Dominance Long Description](#)

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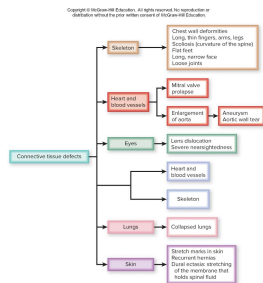
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## Marfan Syndrome



[Jump to Marfan Syndrome Long Description](#)

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# Mendelian Inheritance

## Beyond Mendelian Inheritance (6)

### X-Linked Inheritance

- In mammals
  - The X and Y chromosomes determine gender.
  - Females are XX.
  - Males are XY.

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## Extending the Range of Mendelian Genetics (1)

### X-Linked Inheritance

- The term **X-linked** is used for genes that have nothing to do with gender.
  - X-linked genes are carried on the X chromosome.
  - The Y chromosome does not carry these genes.
- It was discovered in the early 1900s by a group at Columbia University, headed by Thomas Hunt Morgan.
  - Performed experiments with fruit flies
    - They can be easily and inexpensively raised in simple laboratory glassware.
  - Fruit flies have the same sex chromosome pattern as humans.
  - Morgan's experiments with X-linked genes apply directly to humans.

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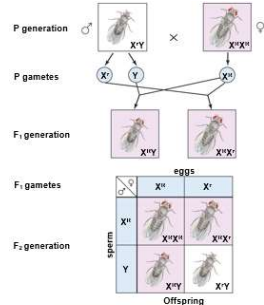
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## X-Linked Inheritance



Allele Key
$X^w$ = red eyes
$X^+$ = white eyes

Phenotypic Ratio
Females: $\frac{1}{2}$ all red-eyed
Males: $\frac{1}{2}$ red-eyed
$\frac{1}{2}$ white-eyed

[Jump to X-Linked Inheritance](#)  
[Long Description](#)

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# Mendelian Inheritance

## Beyond Mendelian Inheritance (7)

Several X-linked recessive disorders occur in humans:

- Color blindness
  - The allele for the blue-sensitive protein is autosomal.
  - The alleles for the red- and green-sensitive pigments are on the X chromosome.
- Menkes syndrome
  - It is caused by a defective allele on the X chromosome.
  - It disrupts movement of the metal copper in and out of cells.
  - Phenotypes include kinky hair, poor muscle tone, seizures, and low body temperature.
- Muscular dystrophy
  - Causes wasting away of the muscle
  - It is caused by the absence of the muscle protein dystrophin.
- Adrenoleukodystrophy
  - It is an X-linked recessive disorder.
  - It is a failure of a carrier protein to move either an enzyme or very long chain fatty acid into peroxisomes.
- Hemophilia
  - It is an absence or minimal presence of clotting factor VIII or clotting factor IX.
  - An affected person's blood either does not clot or clots very slowly.

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## Hemophilia and the Royal Families of Europe (1)

Hemophilia is called the bleeder's disease because the affected person's blood either doesn't clot correctly or doesn't clot at all.

People with hemophilia bleed internally and externally after injury.

Blood transfusions or clotting factor injections help with the disorder.

The pedigree shows why hemophilia is referred to as "the royal disease."

- Queen Victoria was the first of the royals to carry the gene.
- Eventually it was spread throughout the royal families of Europe through arranged marriages between the English, Spanish, Prussian, and Russian royal families.

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