Chapter 14

Mendel and the Gene Idea

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

Overview:

- What genetic principles account for the passing of traits from parents to offspring?
- During the 1800s, The "**blending**" **hypothesis** is the idea that genetic material from the two parents blends together (like blue and yellow paint blend to make green)

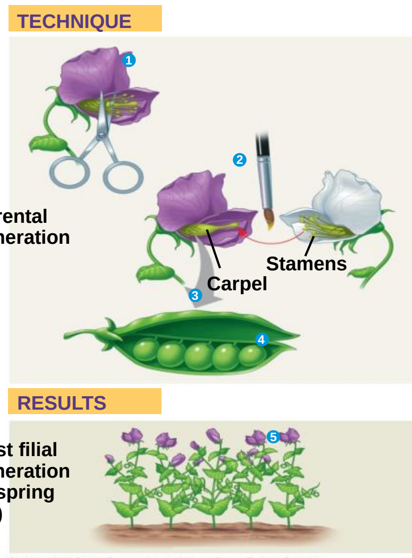
- The “**particulate**” **hypothesis** is the idea that parents pass on **discrete heritable units (genes)**
- **Mendel documented a particulate mechanism** through his experiments with garden peas

Concept 14.1: Mendel used the scientific approach to identify two laws of inheritance

- Mendel discovered the basic principles of heredity by **breeding garden peas** in carefully planned experiments

Fig. 14-2

Crossing pea plants



- Mendel chose to track only those **characters that varied** in an **either-or** manner
- He also used varieties that were **true-breeding** (*plants that produce offspring of the same variety when they self-pollinate*)

- In a typical experiment, Mendel mated two contrasting, true-breeding varieties, a process called **hybridization**
- The true-breeding parents are the **P generation**
- The hybrid offspring of the P generation are called the **F_1 generation**
- When F_1 individuals self-pollinate, the

  F_2 generation is produced

Mendel' first law: The Law of Segregation

- When Mendel crossed contrasting, true-breeding **white** and **purple** flowered pea plants, all of the F_1 hybrids were purple
- When Mendel crossed the F_1 hybrids, many of the F_2 plants had purple flowers, but some had white
- Mendel discovered a ratio of about **three to one**, purple to white flowers, in the F_2 generation

Fig. 14-3-1

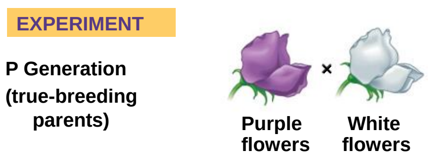


Fig. 14-3-2

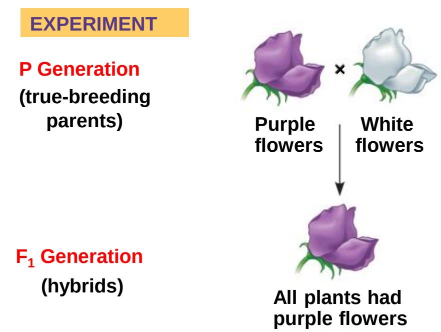
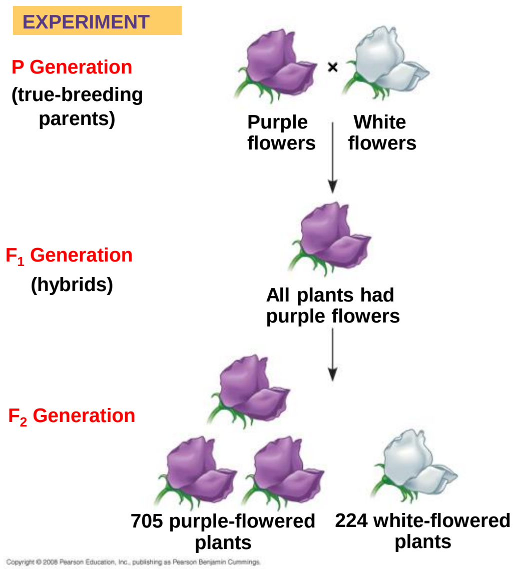


Fig. 14-3-3



- Mendel called the **purple flower** color a **dominant trait** and the **white flower** color a **recessive trait**
- Mendel observed the same pattern of inheritance in six other pea plant characters, each represented by two traits
- What Mendel called a "heritable factor" is what we now call a gene

Class activity!

- If you mated two purple-flowered plants from the P-generation, what ratio of traits would you expect to observe in the offspring?

Table 14-1

Table 14.1 The Results of Mendel's F_1 Crosses for Seven Characters in Pea Plants

Character	Dominant Trait	x	Recessive Trait	F_2 Generation Dominant:Recessive	Ratio
Flower color	Purple	×	White	705:224	3.15:1
Flower position	Axial	×	Terminal	651:207	3.14:1
Seed color	Yellow	×	Green	6,022:2,001	3.01:1
Seed shape	Round	×	Wrinkled	5,474:1,850	2.96:1
Pod shape	Inflated	×	Constricted	882:299	2.95:1
Pod color	Green	×	Yellow	428:152	2.82:1
Stem length	Tall	×	Dwarf	787:277	2.84:1

The law of segregation states that *the two alleles for a heritable character separate (segregate) during gamete formation and end up in different gametes*

- Thus, an egg or a sperm gets only one of the two alleles that are present in the somatic cells of an organism

- Mendel's segregation model accounts for the **3:1 ratio** he observed in the F_2 generation of his numerous crosses
- The possible combinations of sperm and egg can be shown using a **Punnett square**, a diagram for predicting the results of a genetic cross between individuals of known genetic makeup
- A capital letter represents a dominant allele, and a lowercase letter represents a recessive allele

Fig. 14-5-1

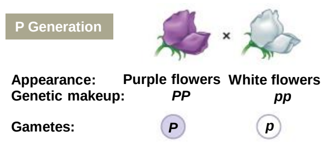


Fig. 14-5-2

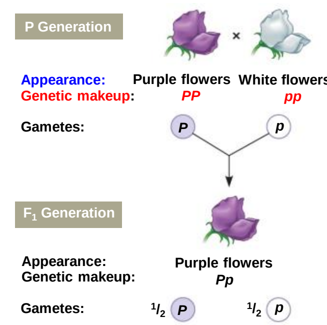
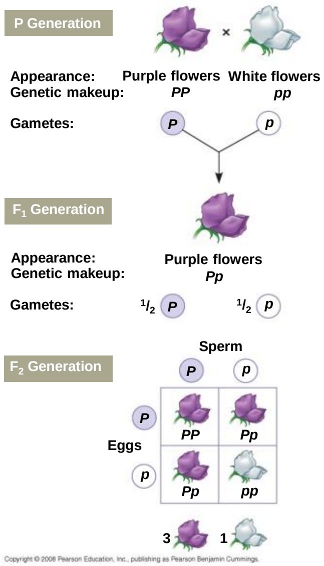


Fig. 14-5-3

Mendel's law of segregation

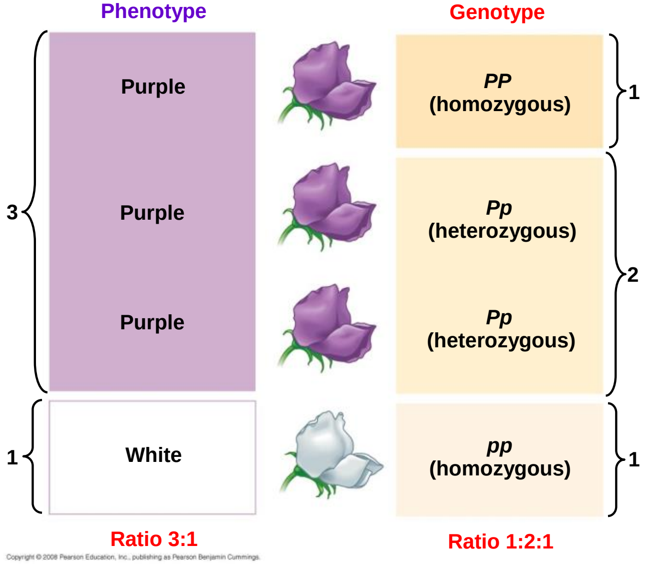


Useful Genetic Vocabulary

- An organism with **two identical alleles** for a character is said to be **homozygous** for the gene controlling that character
- An organism that has **two different alleles** for a gene is said to be **heterozygous** for the gene controlling that character

- An organism's physical appearance: is called its **phenotype**
- An organism's genetic makeup is called its **genotype.**
- In the example of flower color in pea plants, ***PP*** and ***Pp*** plants have the same phenotype (purple) but different genotypes

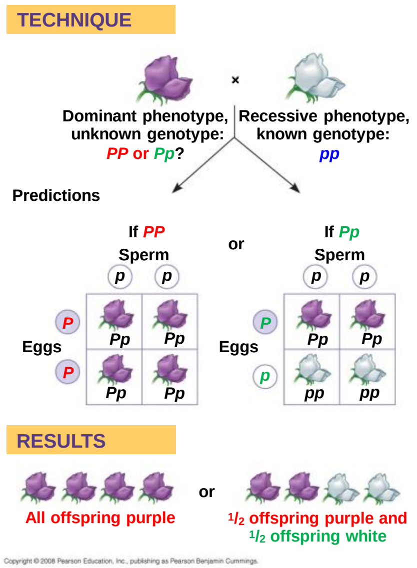
Fig. 14-6



The Testcross

- Used to determine **the genotype** of an organism that shows the **dominant phenotype**?
- Such an individual must have one dominant allele, but the individual could be either homozygous dominant or heterozygous
- The answer is to carry out a **testcross**: *breeding the mystery individual with a homozygous recessive individual*
- If any offspring display the recessive phenotype, the mystery parent must be heterozygous

Fig. 14-7



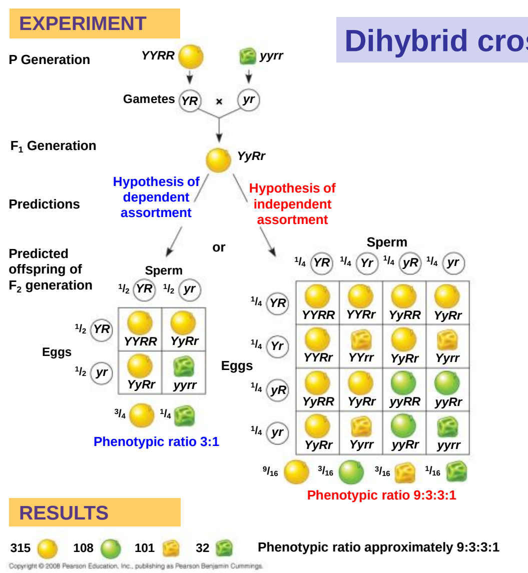
Mendel's second law: The Law of Independent Assortment

- Mendel derived the law of segregation by following a single character
- The F_1 offspring produced in this cross were **monohybrids**, *individuals that are heterozygous for one character*
- A cross between such heterozygotes is called a *monohybrid cross*

- Mendel identified his **second law of inheritance** by following two characters at the same time
- Crossing two true-breeding parents differing in two characters produces **dihybrids** in the F_1 generation, heterozygous for both characters
- A dihybrid cross, a cross between F_1 dihybrids, *can determine whether two characters are transmitted to offspring as a package or independently*

Fig. 14-8

Dihybrid cross



- The **law of independent assortment** states that each pair of alleles segregates independently of each other pair of alleles during gamete formation
- Strictly speaking, this law applies only to genes on different, nonhomologous chromosomes
- Genes located near each other on the same chromosome tend to be inherited together

Concept 14.3: Inheritance patterns are often more complex than predicted by simple Mendelian genetics

- The relationship between genotype and phenotype is rarely as simple as in the pea plant characters Mendel studied
- Many heritable characters are not determined by only one gene with two alleles
- However, the basic principles of segregation and independent assortment apply even to more complex patterns of inheritance

Extending Mendelian Genetics for a Single Gene

- Inheritance of characters by a single gene may deviate from simple Mendelian patterns in the following situations:
  - **When alleles are not completely dominant or recessive**
  - **When a gene has more than two alleles**
  - **When a gene produces multiple phenotypes**

Degrees of Dominance

- **Complete dominance** occurs when phenotypes of the heterozygote and dominant homozygote are identical
- In **incomplete dominance**, the phenotype of F_1 hybrids is somewhere between the phenotypes of the two parental varieties. Example: *Snapdragon flower color*
- In **codominance**, two dominant alleles affect the phenotype in separate, distinguishable ways. **Example: blood groups (A & B)**

Fig. 14-10-1

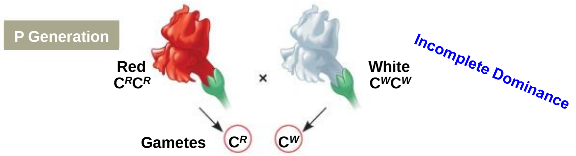
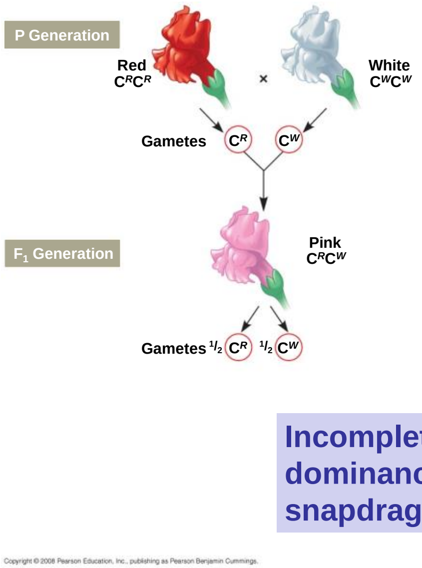
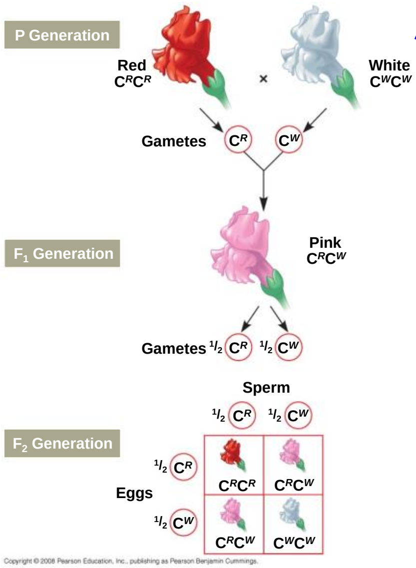


Fig. 14-10-2



Incomplete dominance in snapdragon color

Fig. 14-10-3



Incomplete Dominance

Multiple Alleles

- Most genes exist in populations in more than two allelic forms
- For example, the **four phenotypes** of the ABO blood group in humans are determined by **three alleles** for the enzyme (I) that attaches A or B carbohydrates to red blood cells: ***I^A, I^B,*** and ***i.***
- The enzyme encoded by the ***I^A*** allele adds the **A** carbohydrate, whereas the enzyme encoded by the ***I^B*** allele adds the **B** carbohydrate; the enzyme encoded by the ***i*** allele **adds neither**

Fig. 14-11