Figure 7-1
***What Is Life? A Guide To Biology*, Second Edition**

Genes and Inheritance

(11-12)

You are a unique combination of your two parents

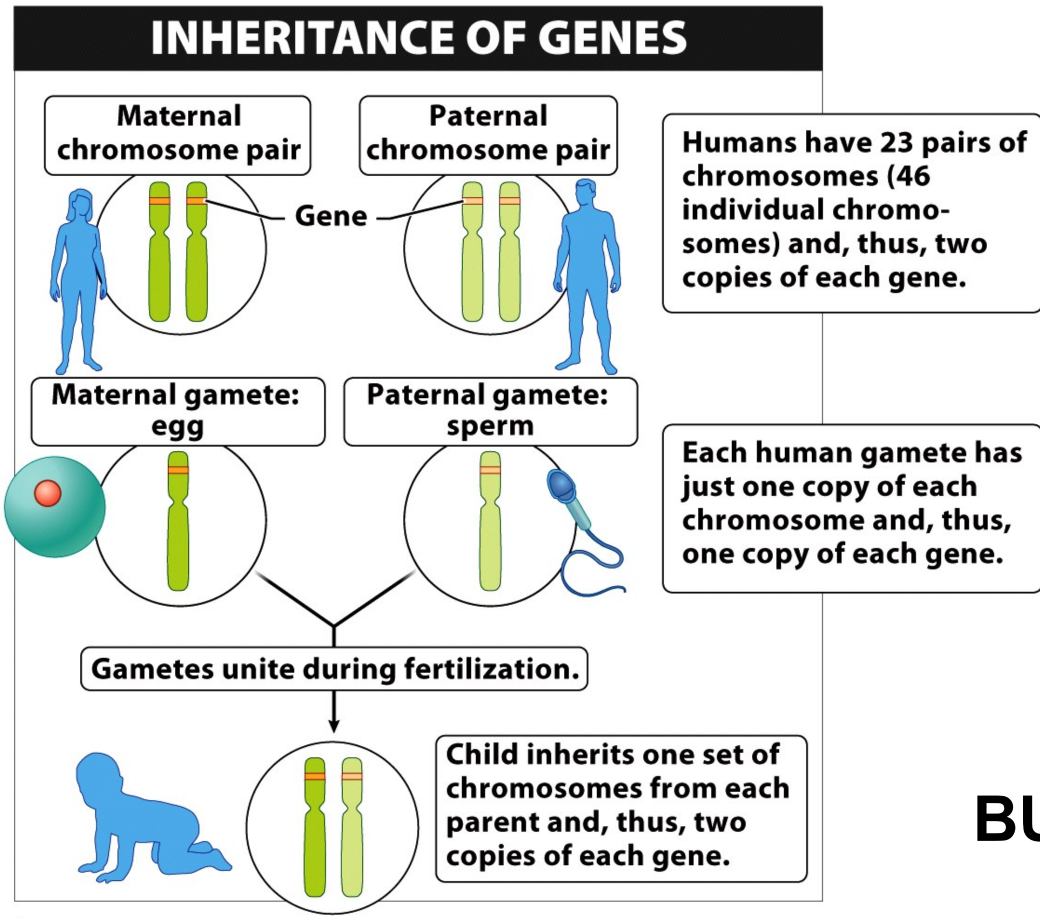


Figure 7-2
What Is Life? A Guide To Biology

- We all have two copies of each gene (one maternal and one paternal)
- Gametes produced via **meiosis** contain only one copy of each gene
- Fusion of gametes during **fertilization** produces offspring with two copies of each gene

BUT WE DIDN'T ALWAYS KNOW THIS!!

People used to think that a tiny baby was transferred via sperm or that traits from both parents were blended through exchange of blood

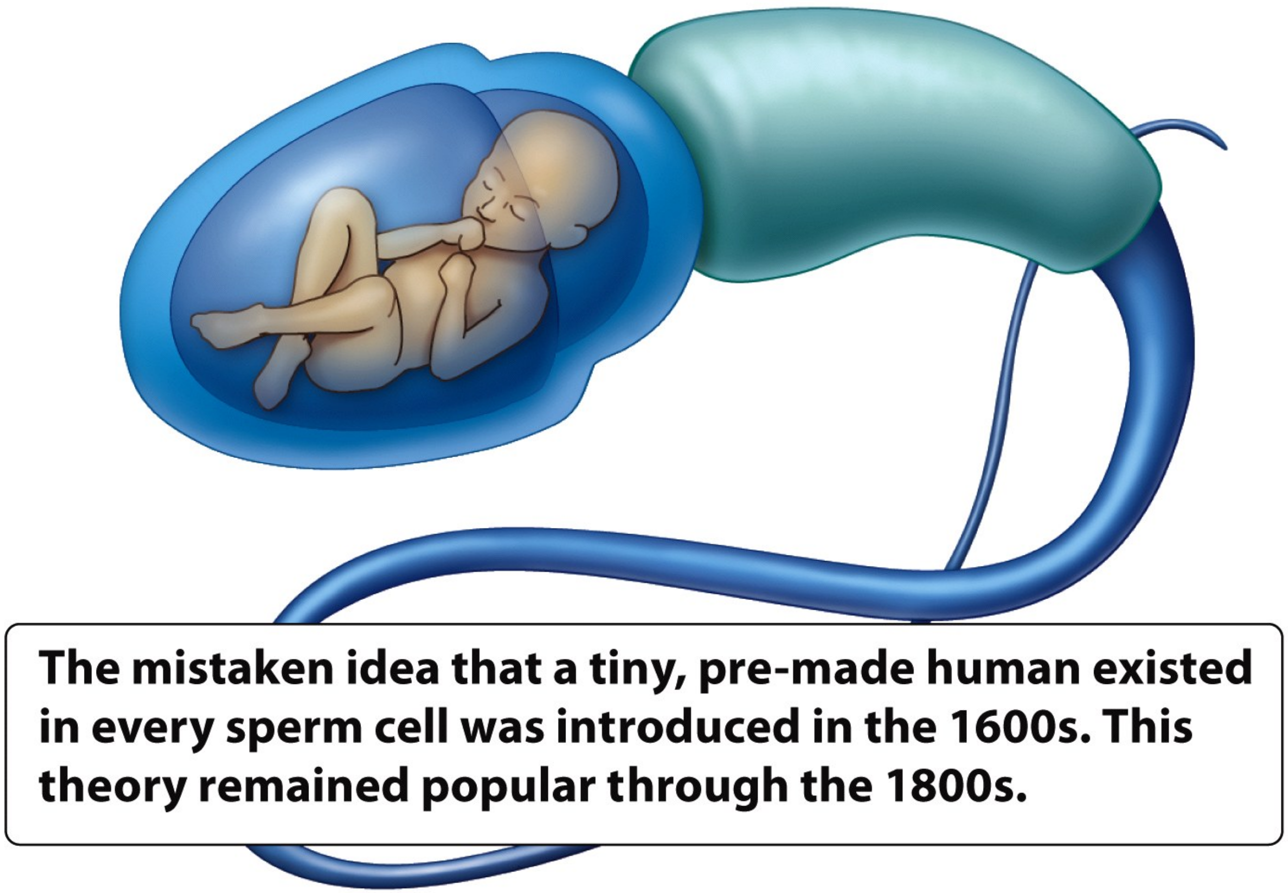


Figure 7-6
What Is Life? A Guide To Biology

Gregor Mendel **(1822-1884)**

“Father of Genetics”

(first to understand and define the rules of inheritance)

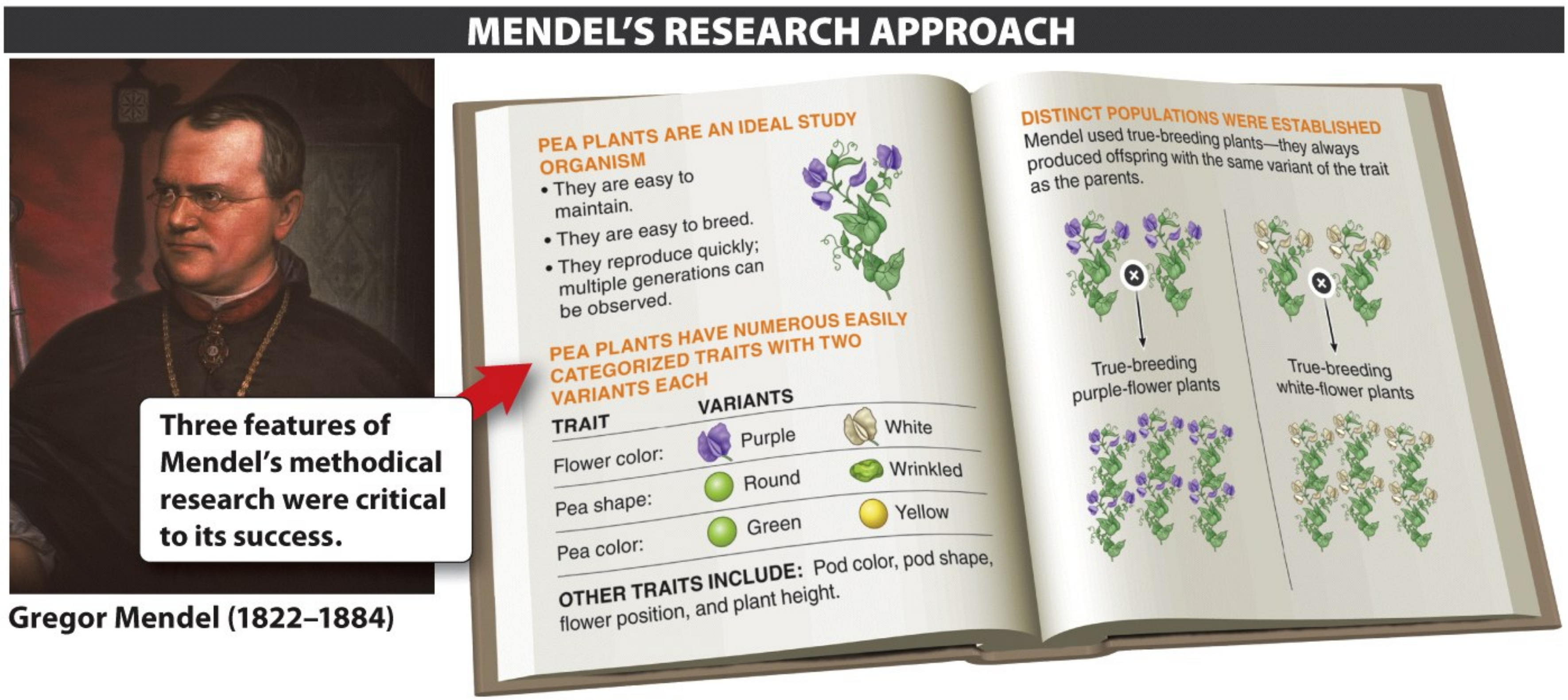
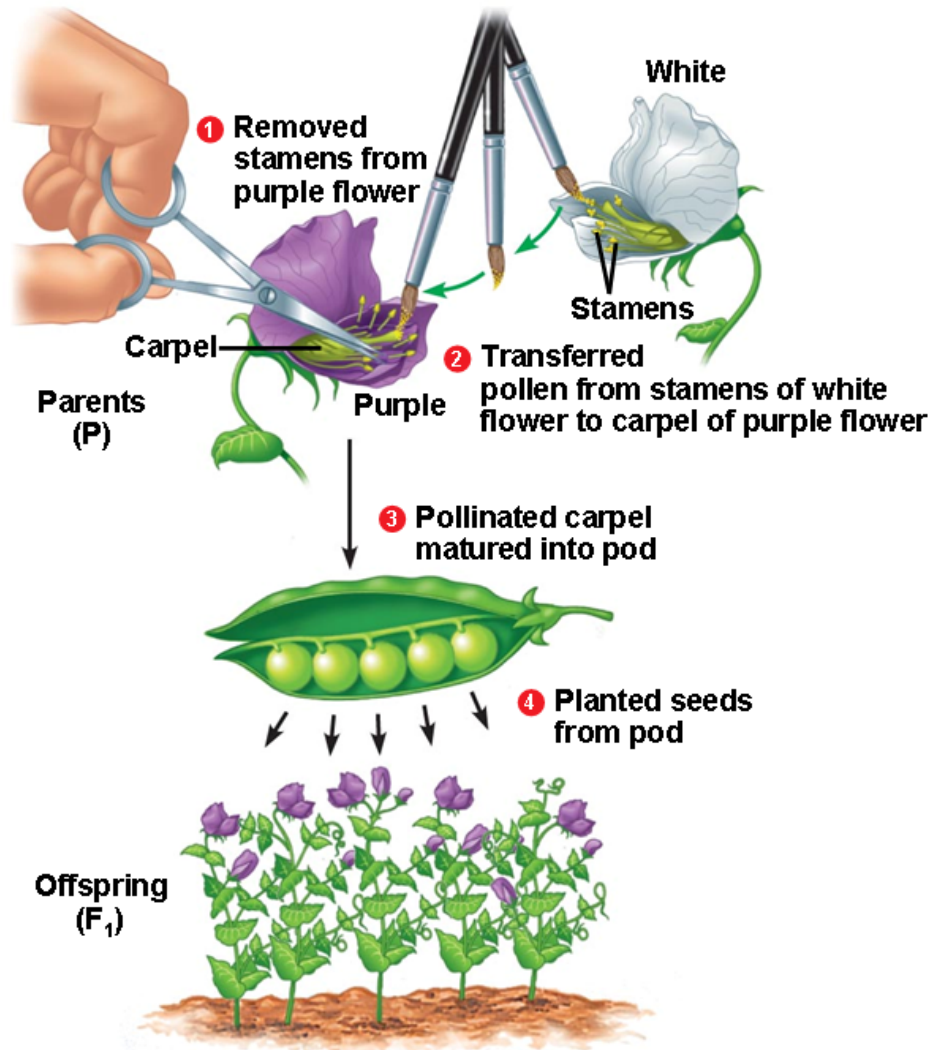


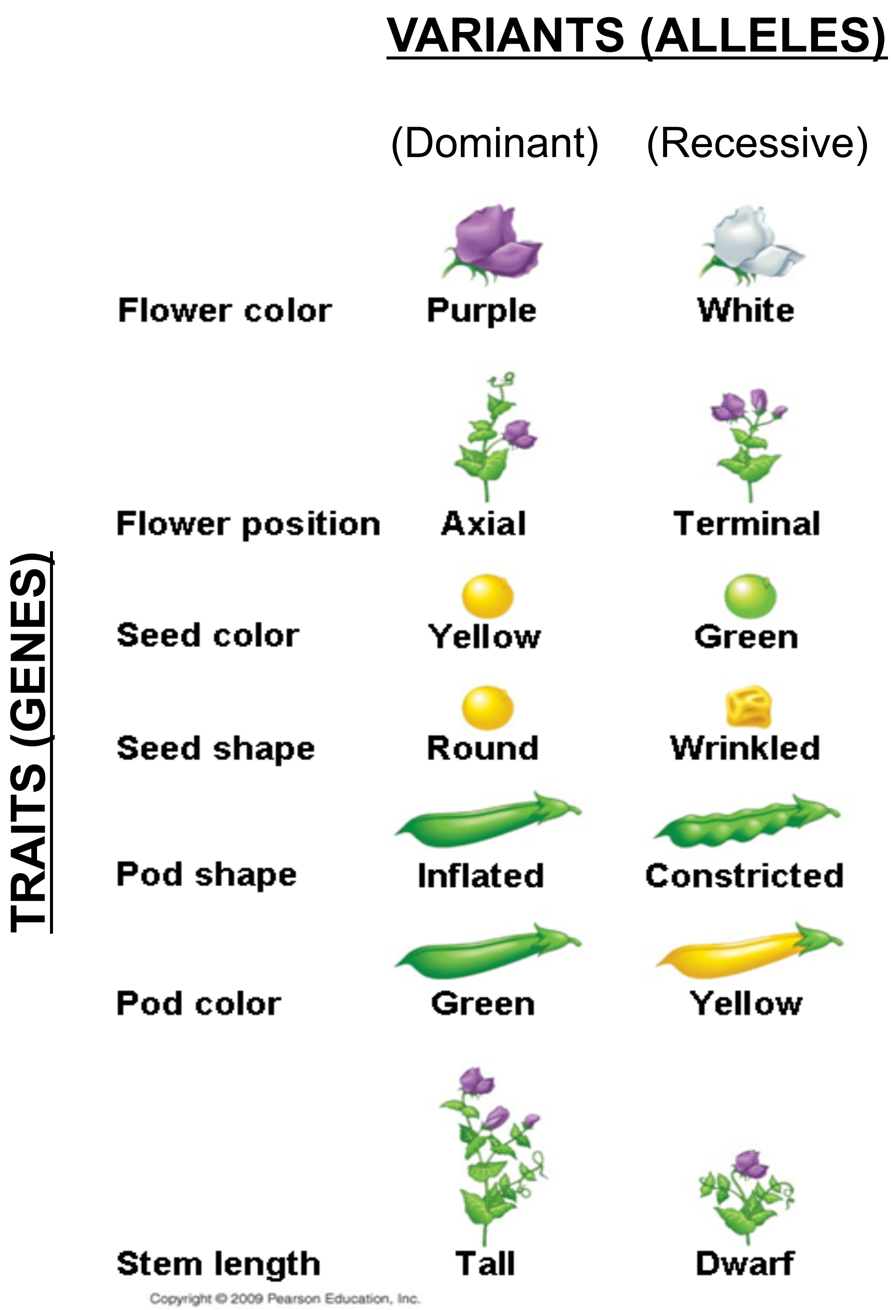
Figure 7-7
***What Is Life? A Guide To Biology*, Second Edition**

Mendel could control mating and produce lots of offspring

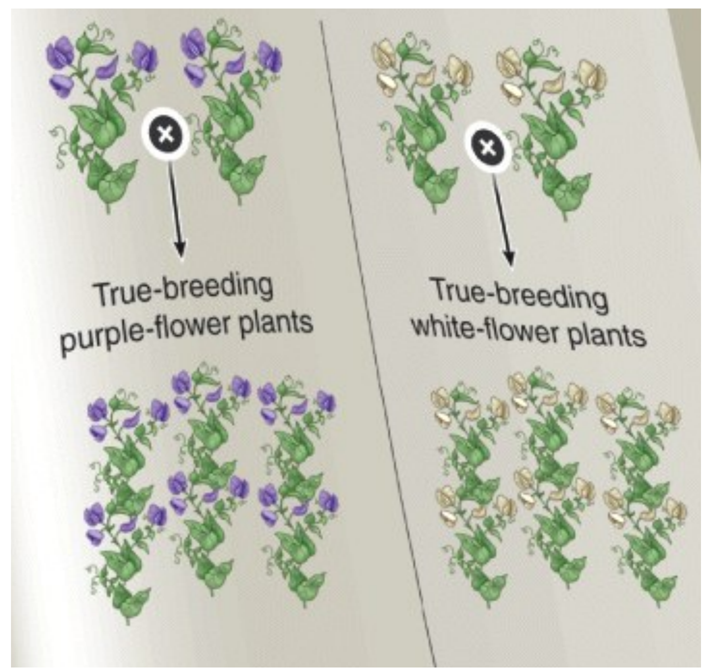
Self-fertilization = fertilization of egg and sperm within the same plant

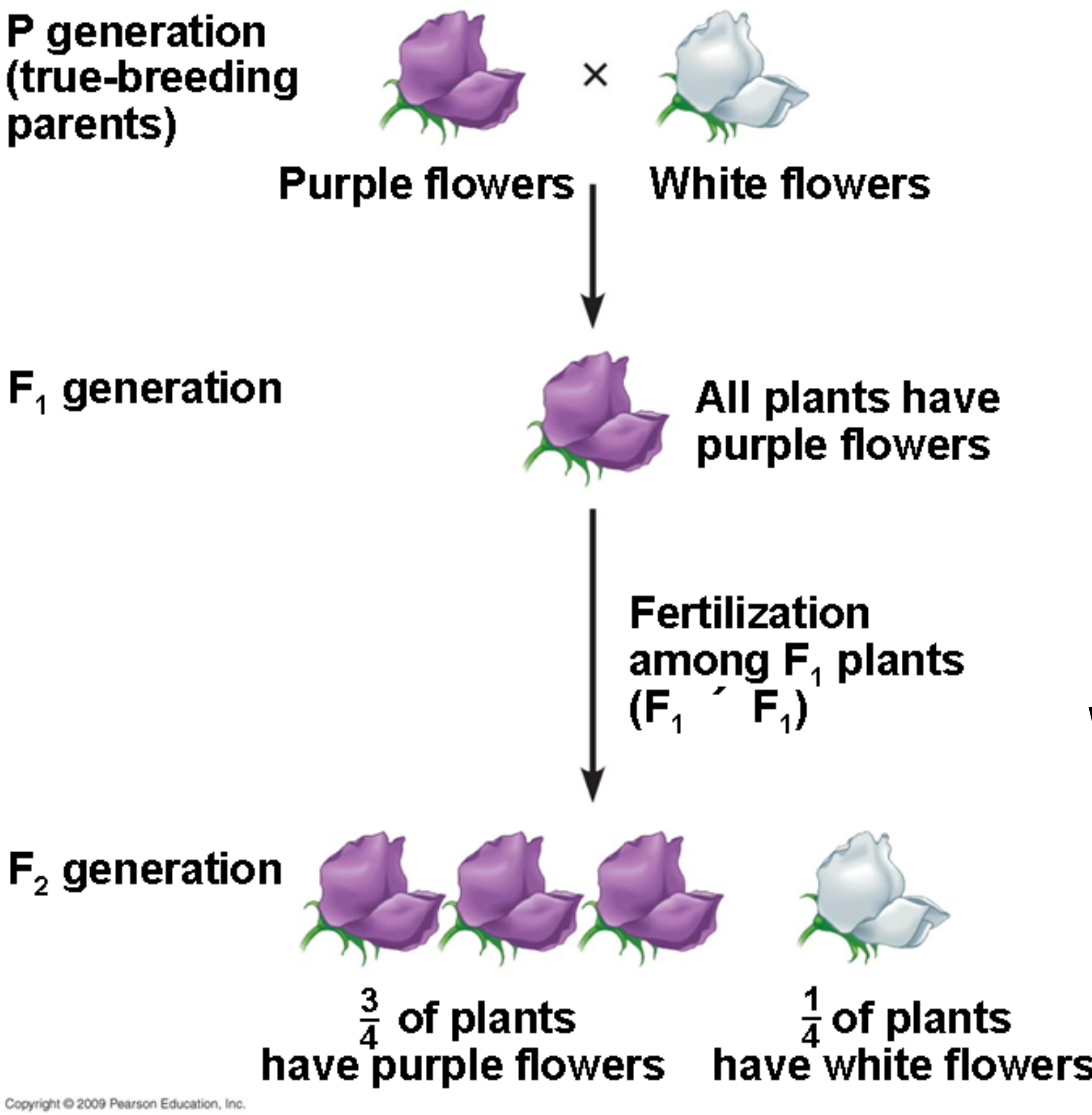
Cross-fertilization = fertilization of one plant by pollen from a different plant





True Breeding = varieties for which self-fertilization produces offspring all identical to the parent





Mendel started crossing two different true-breeding plants for one trait

Which flower color allele is dominant?

Mendel's Three Hypotheses of Inheritance

1) Gametes carry only one copy of each gene because homologous chromosomes separate (segregate) during meiosis = **Law of Segregation**

2) An organism inherits one gene from each parent **(Genotype)**
   - Homozygous vs. Heterozygous

3) Inherited genes determine the outer appearance of the organism **(Phenotype)**
   - Dominant vs. Recessive

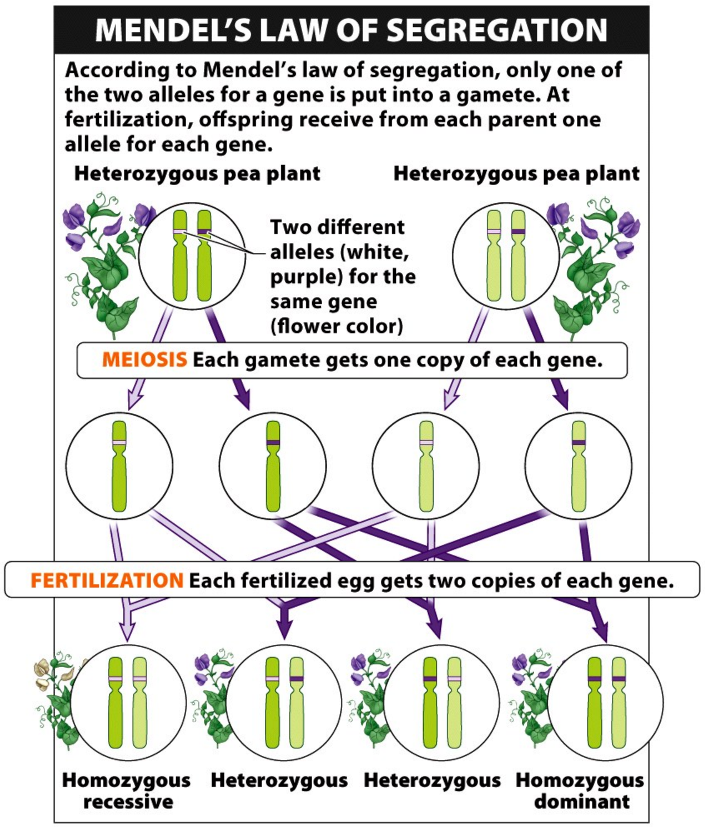
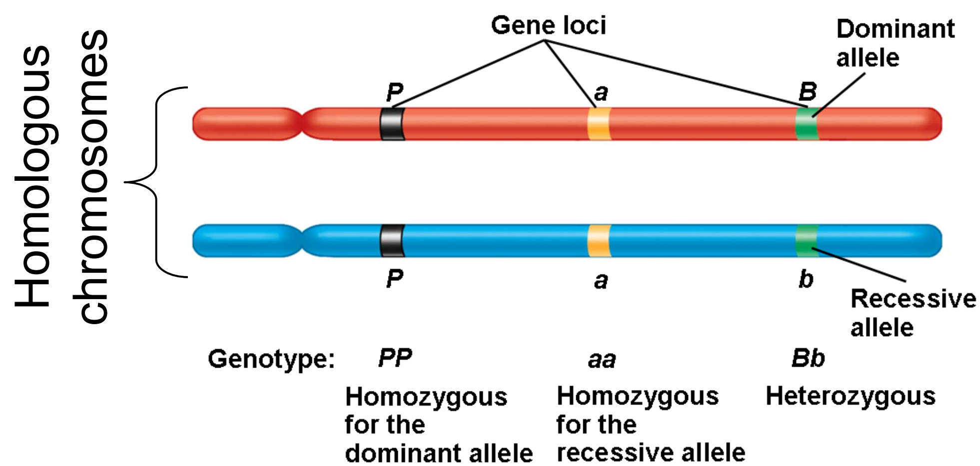
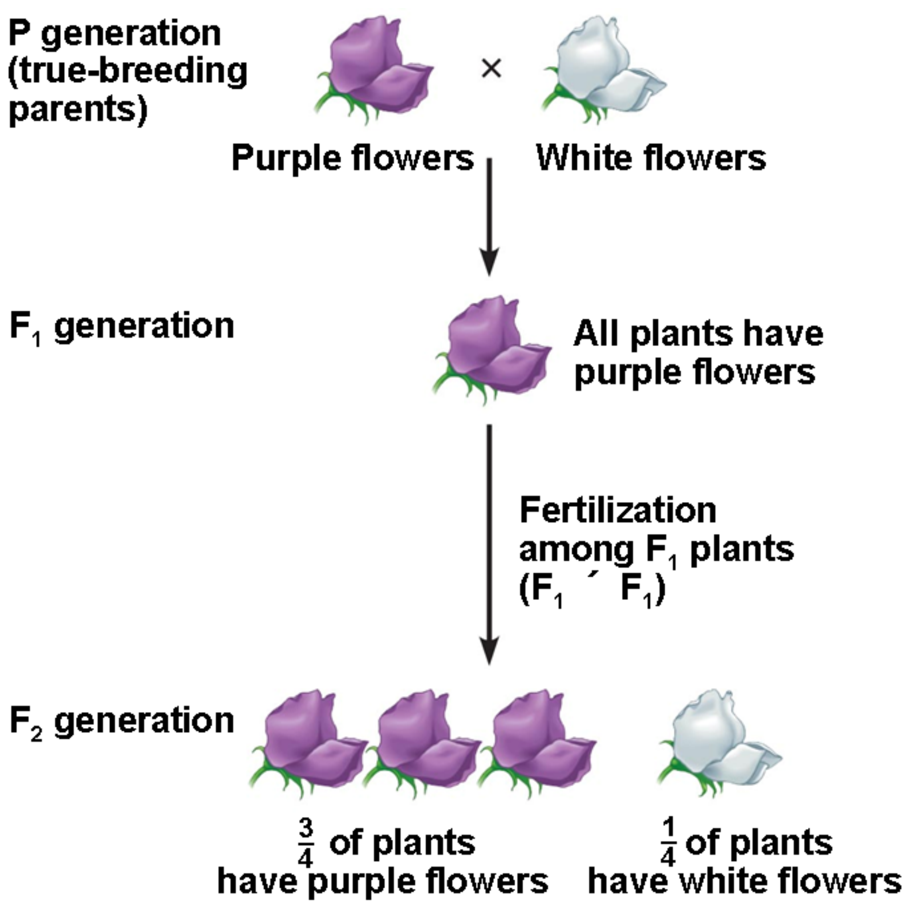
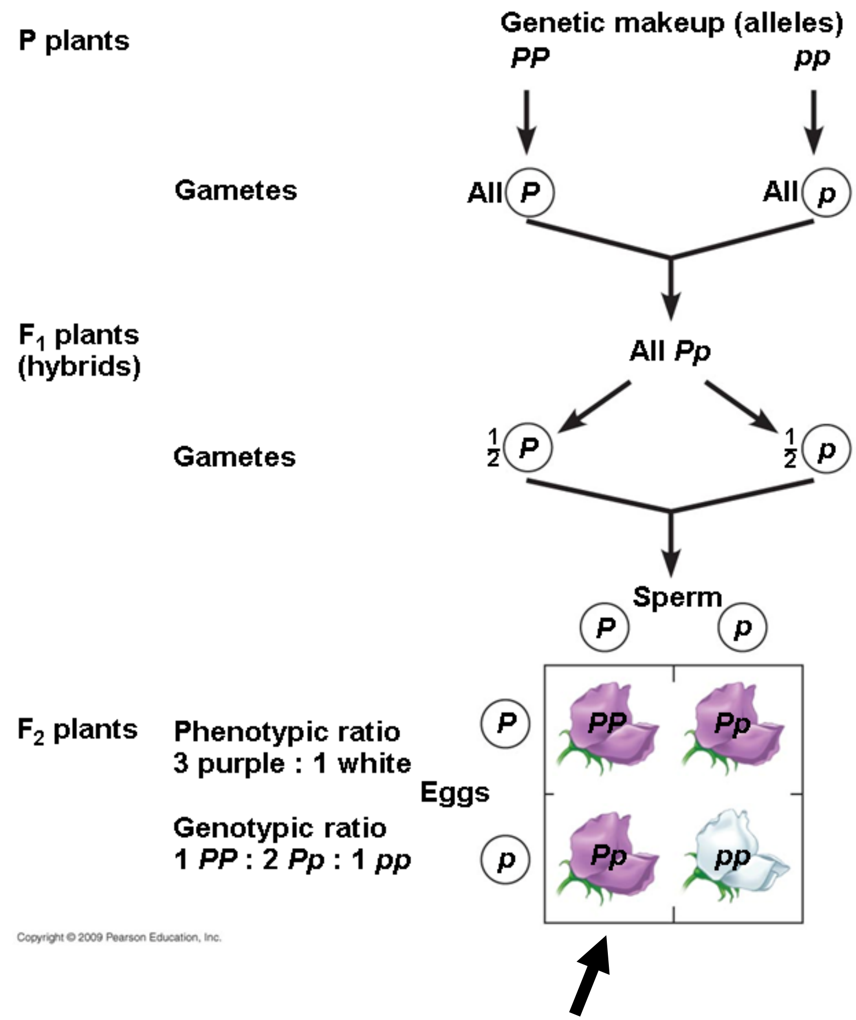


Figure 7-9
What Is Life? A Guide To Biology



Were Mendel's hypotheses correct?





PUNNETT SQUARE = used to predict inheritance of future generation

New alleles arise through mutation

The dominant curled ears allele was caused by a mutation. Cross a heterozygous and homozygous recessive cat and give the expected genotypic and phenotypic ratios of the offspring.

Genotypic ratio?

Phenotypic ratio?

Genetics involves **probability** and **chance**

Albinism is caused by a recessive allele for pigmentation.

What are the chances that an **albino female** and a **heterozygous male** will have an albino offspring?

PHENOTYPE: Little or no pigment in the eyes, hair, and skin
GENOTYPE: Homozygous for the recessive allele for albinism

Figure 7-10
What Is Life? A Guide To Biology, Second Edition

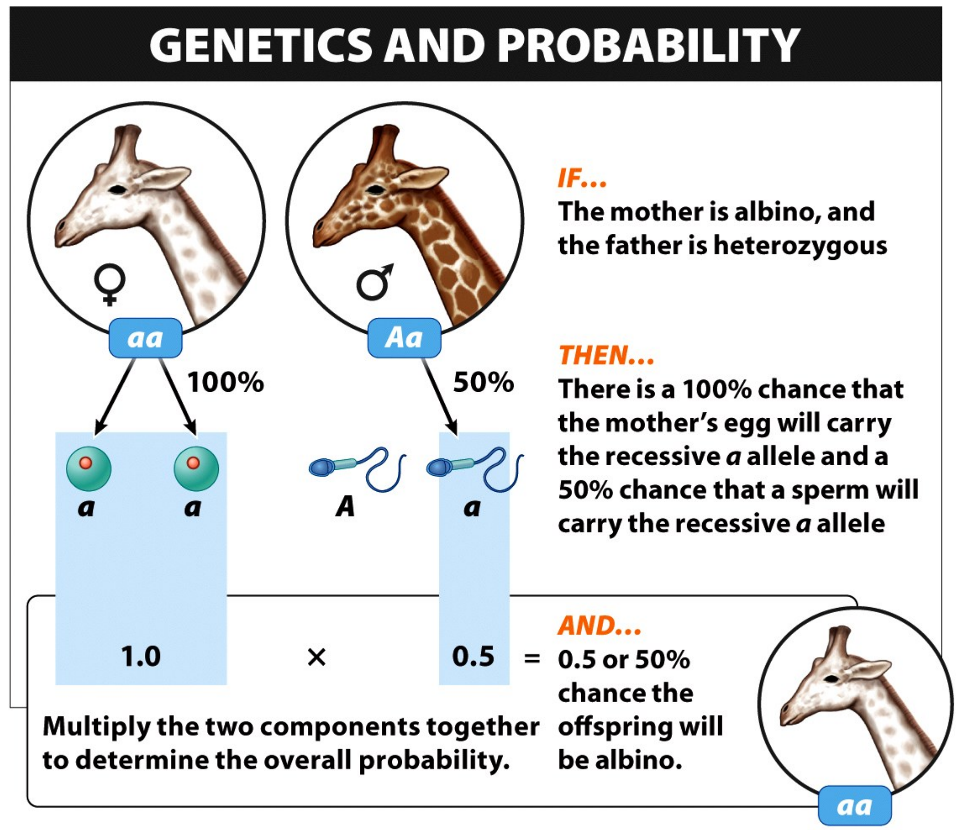


Figure 7-12
What Is Life? A Guide To Biology

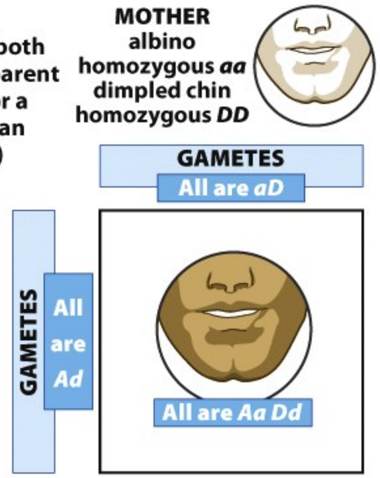
MENDEL'S LAW OF INDEPENDENT ASSORTMENT

Mendel's law of independent assortment states that one trait does not influence the inheritance of another trait.

IF...

Parents are both homozygous for both traits. (But each parent is homozygous for a different allele than the other parent.)

MOTHER
albino
homozygous ***aa***
dimpled chin
homozygous ***DD***



FATHER
pigmented
homozygous ***AA***
non-dimpled chin
homozygous ***dd***

THEN...

All offspring are heterozygous for both traits (i.e., "doubly heterozygous"): ***Aa Dd*** (and exhibit the dominant trait in their phenotype).

OFFSPRING	GENOTYPE	PHENOTYPE
	All heterozygous ***Aa***	All pigmented
	All heterozygous ***Dd***	All dimpled chin

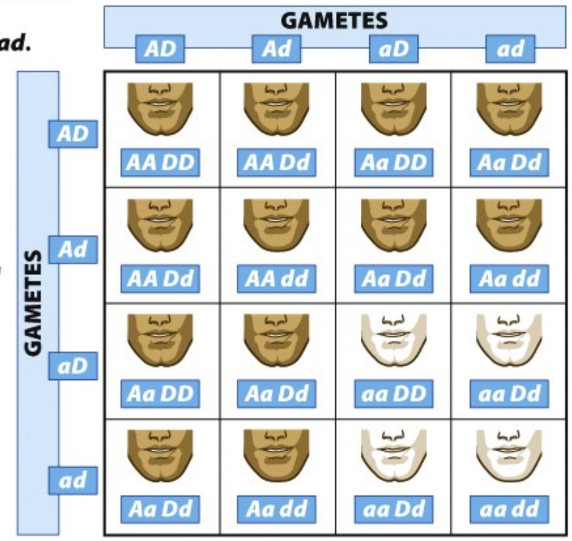
In this example, having a dimpled chin does not affect which alleles are inherited for skin pigmentation.

IF...

Parents are both heterozygous for both traits (i.e., "doubly heterozygous"). Four different types of gametes are produced by each: ***AD***, ***Ad***, ***aD***, and ***ad***.

MOTHER
pigmented
heterozygous ***Aa***
dimpled chin
heterozygous ***Dd***

FATHER
pigmented
heterozygous ***Aa***
dimpled chin
heterozygous ***Dd***



THEN...

The genotype proportions for ***A/a*** are still ¼ ***AA***, ½ ***Aa***, and ¼ ***aa***. And the genotype proportions for ***D/d*** are still ¼ ***DD***, ½ ***Dd***, and ¼ ***dd***.

OFFSPRING	GENOTYPE	PHENOTYPE
	1/4 homozygous dominant ***AA***	3/4 pigmented
	2/4 heterozygous ***Aa***	
	1/4 homozygous recessive ***aa***	1/4 albino
	1/4 homozygous dominant ***DD***	3/4 dimpled chin
	2/4 heterozygous ***Dd***	
	1/4 homozygous recessive ***dd***	1/4 non-dimpled chin

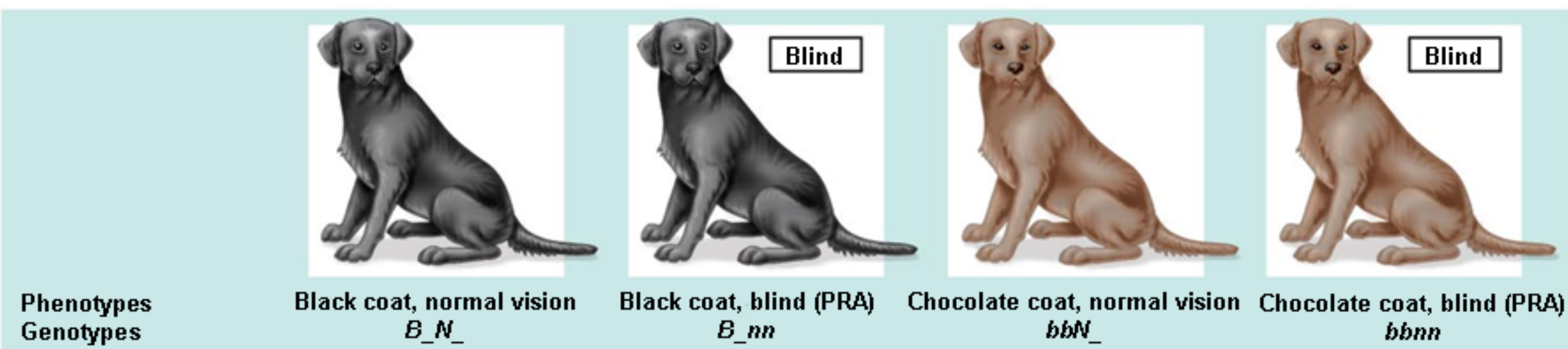
Figure 7-27

***What Is Life? A Guide To Biology*, Second Edition**

Labradors have a gene for coat color and a gene for vision.

What are the chances that a **heterozygous female for coat color and homozygous dominant for vision** and a **heterozygous male for both traits** will have:

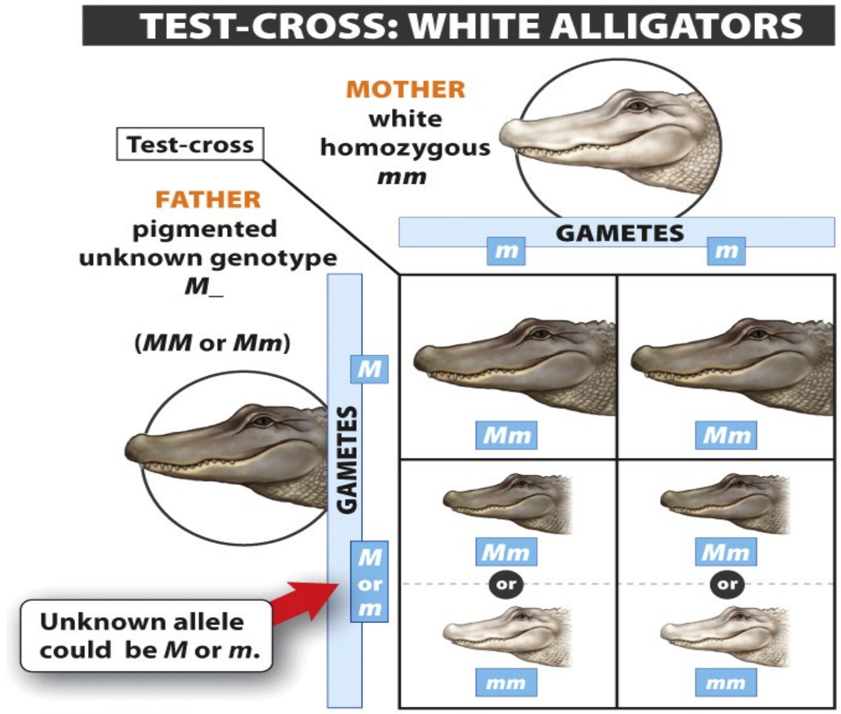
- A black-coated and normal vision offspring?
- A black-coated and blind offspring?
- A chocolate-coated and normal vision offspring?
- A chocolate-coated and blind offspring?



A **Test cross** can be used to determine genotype in individuals that display the dominant phenotype

- May be homozygous dominant or heterozygous
- Cross with homozygous recessive to find out…

Figure 7-14 part 1
What Is Life? A Guide To Biology, Second Edition



OFFSPRING (if unknown genotype is *MM*)

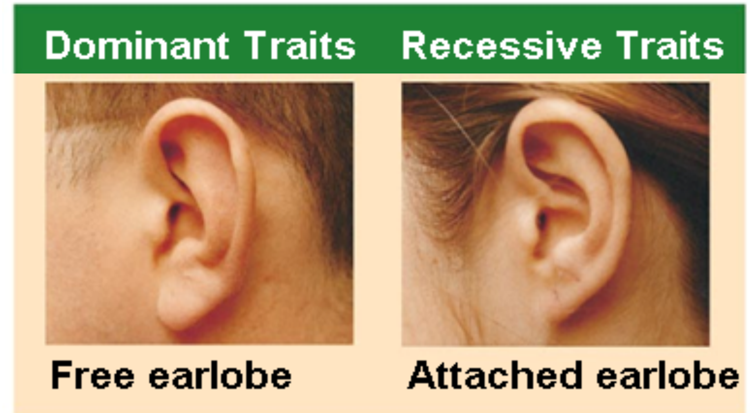
	GENOTYPE	PHENOTYPE
	All heterozygous *Mm*	All pigmented

OFFSPRING (if unknown genotype is *Mm*)

	GENOTYPE	PHENOTYPE
	2/4 heterozygous *Mm*	2/4 pigmented
	2/4 homozygous recessive *mm*	2/4 white

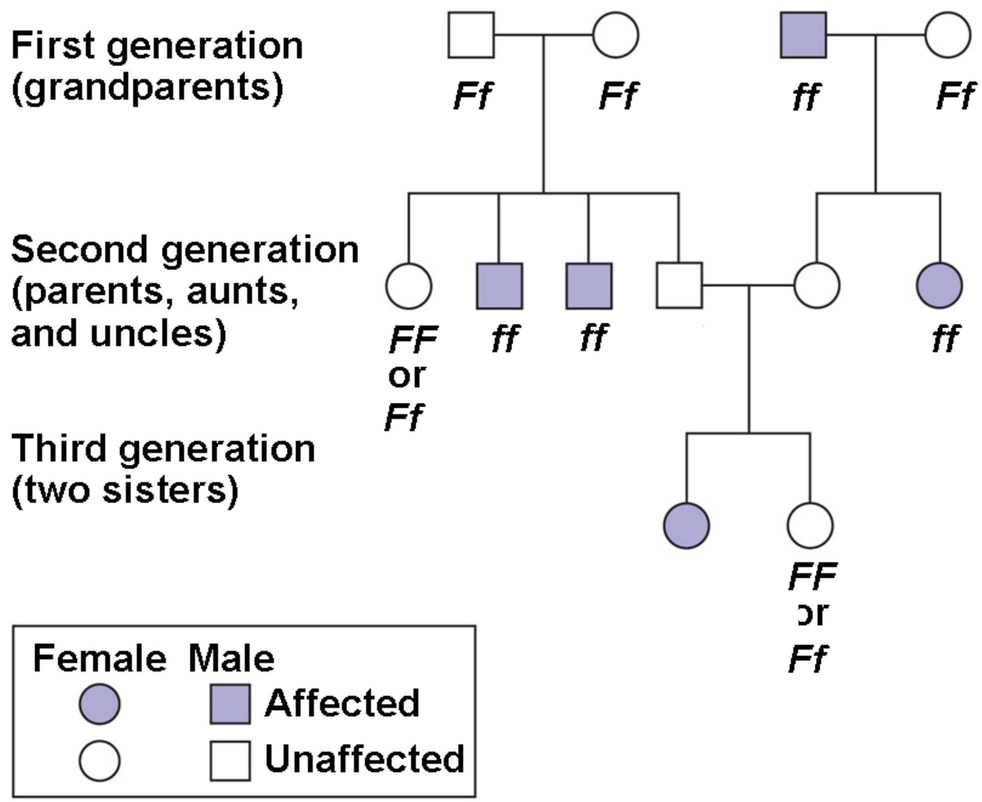
Figure 7-14 part 2
What Is Life? A Guide To Biology, Second Edition

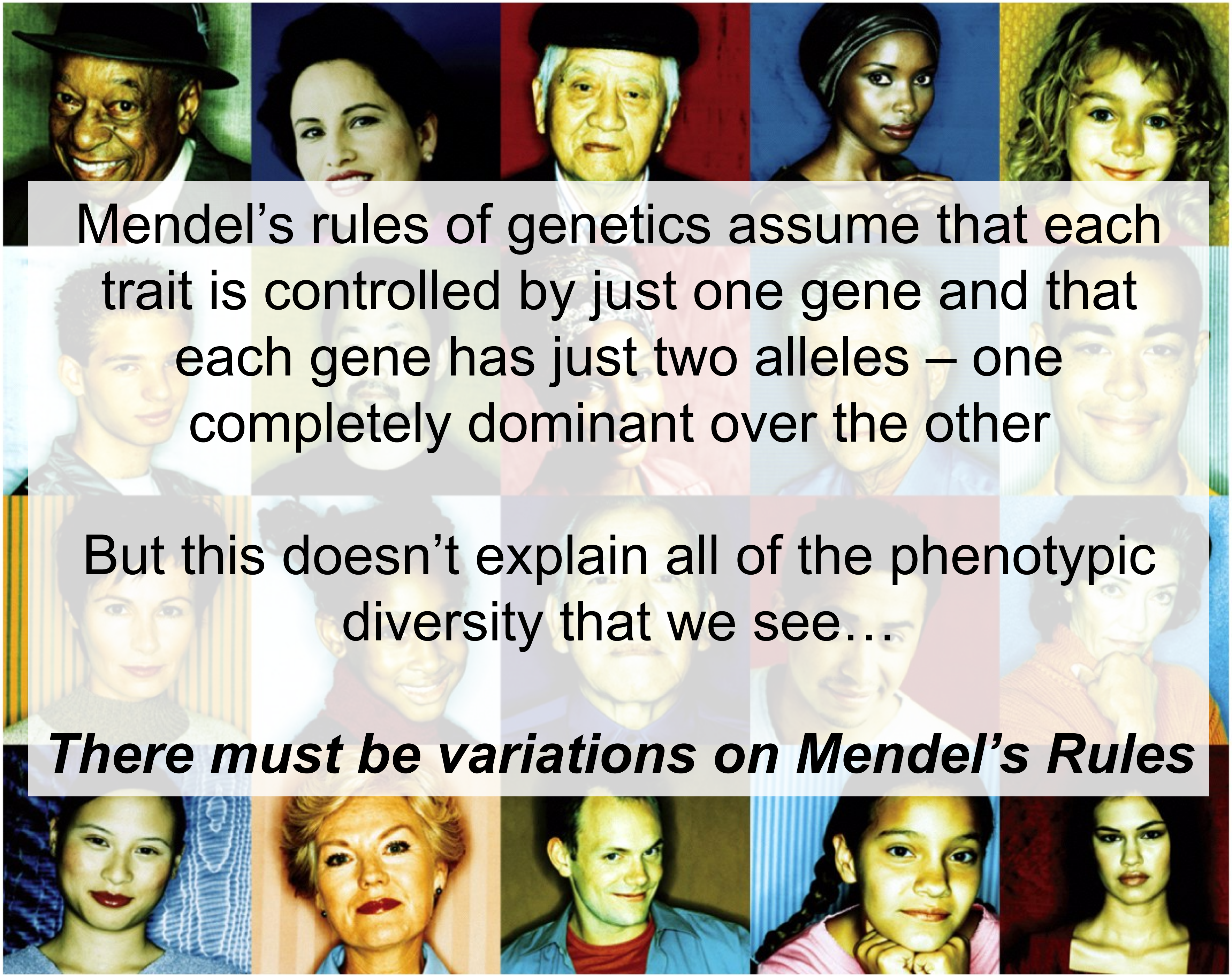
Genetic traits can be tracked through family pedigrees



Pedigree = family tree representing the occurrence of heritable traits in parents and offspring across a number of generations

- can determine genotype based on phenotype and family relationships





Mendel’s rules of genetics assume that each trait is controlled by just one gene and that each gene has just two alleles – one completely dominant over the other

But this doesn’t explain all of the phenotypic diversity that we see…

There must be variations on Mendel’s Rules

Variations on Mendel's rules of genetics – **Incomplete Dominance**

- The phenotype of a heterozygote appears to be ***intermediate*** between that of the two homozygotes

- No dominant or recessive allele – instead phenotype is intermediate between the two

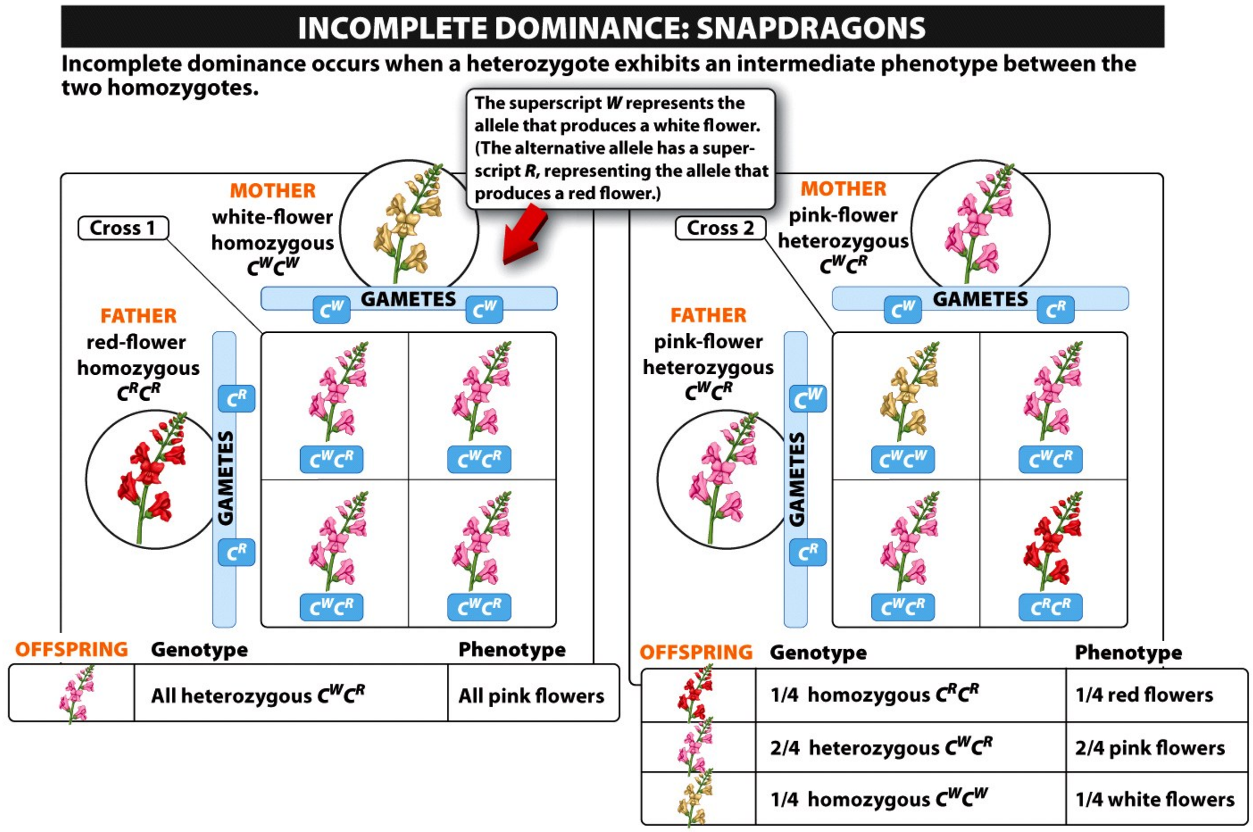
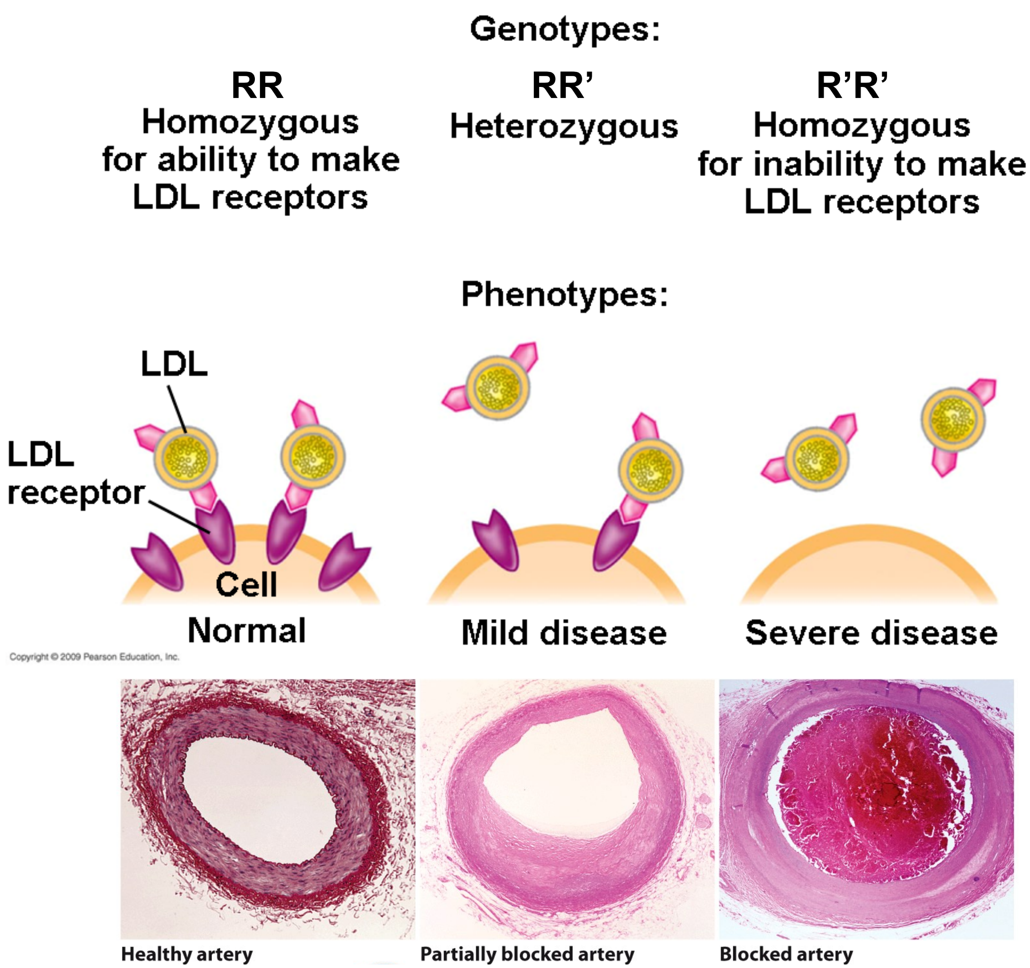


Figure 7-17
What Is Life? A Guide To Biology

In humans, the gene to make LDL receptor proteins has two incompletely dominant alleles: **R** (protein production) and **R'** (no protein production)



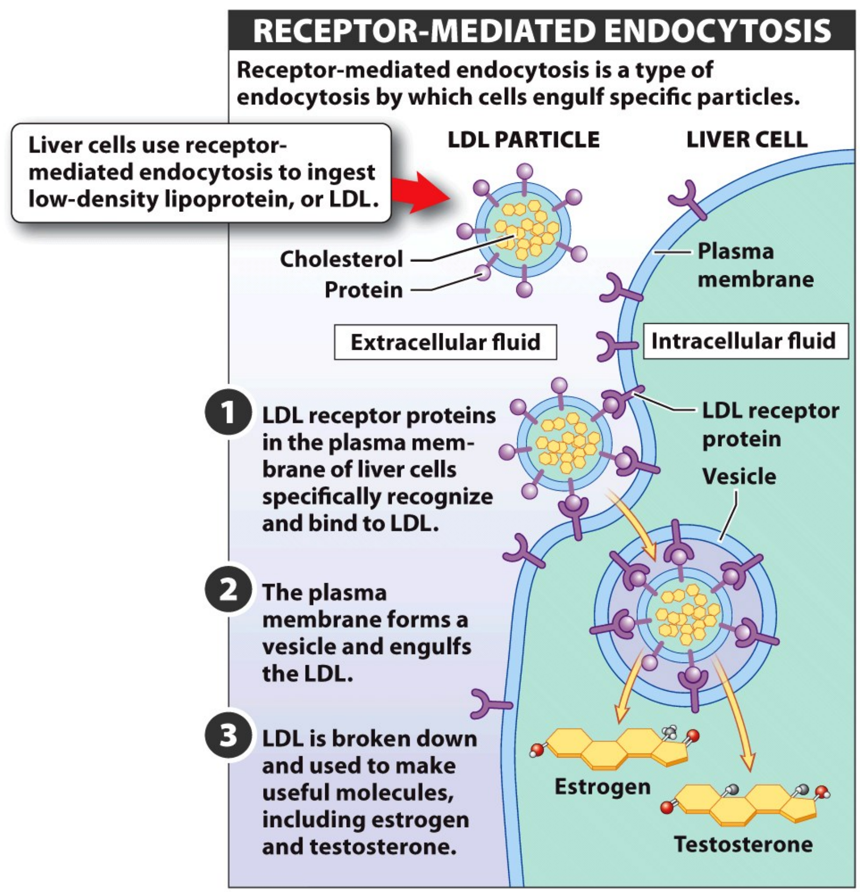


Figure 3-22
What Is Life? A Guide To Biology, Second Edition

Variations on Mendel's rules of genetics – **Multiple alleles**

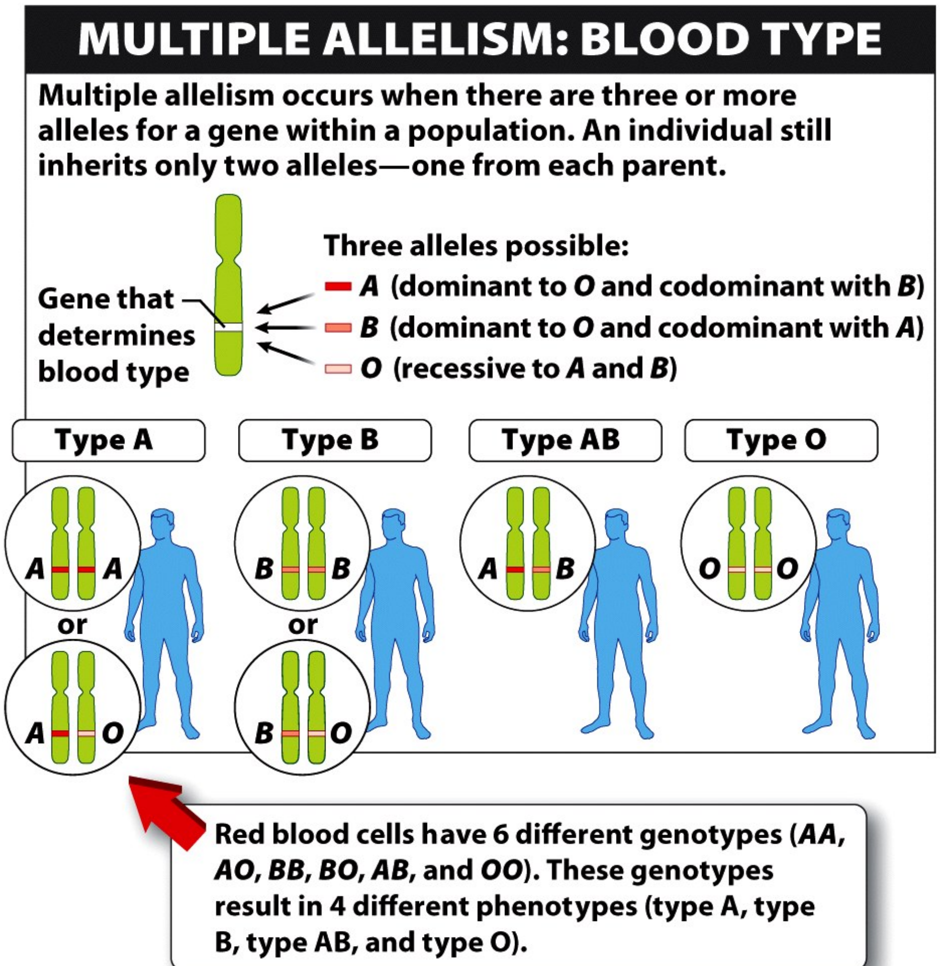


Figure 7-19
What Is Life? A Guide To Biology

- There can be more than two alleles for each gene
- Several phenotypes possible (not just two)

Variations on Mendel's rules of genetics – **Codominance**

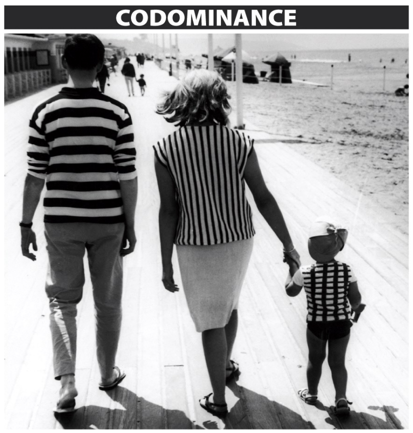


Figure 7-18
What Is Life? A Guide To Biology, Second Edition

- Heterozygotes display characteristics of both homozygotes
- No dominant or recessive allele – instead both phenotypes are displayed

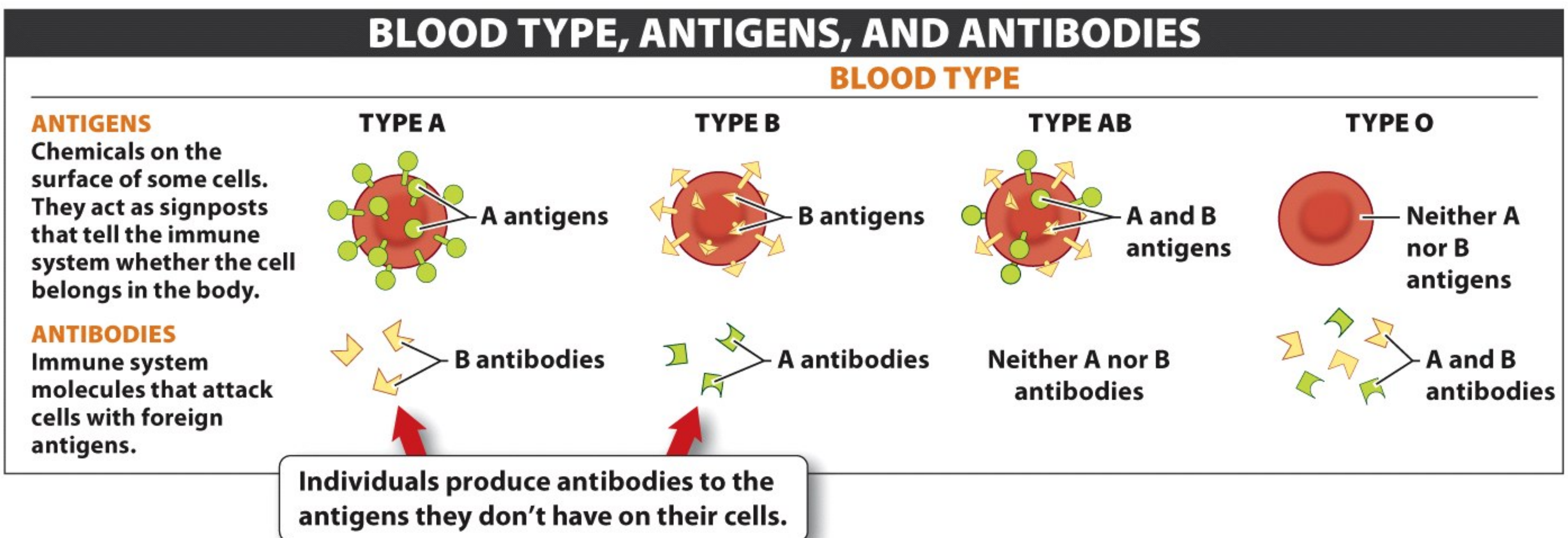
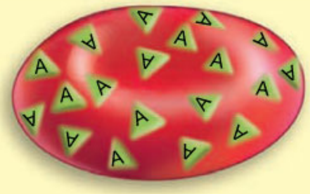
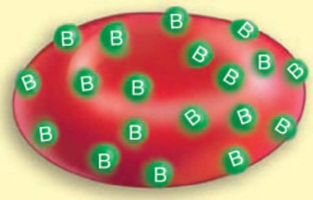
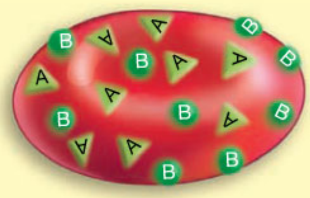
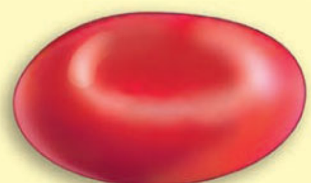


Figure 7-20
What Is Life? A Guide To Biology, Second Edition

Table 11.3

Human Blood Types

This blood type (phenotype) . . .	. . . has these surface glycolipids . . .	. . . and is produced by these genotypes
A		AA or AO
B		BB or BO
AB		AB
O	 (no surface glycolipids)	OO

The familiar ABO human blood-typing system refers to glycolipid molecules that extend from the surface of red blood cells. People whose blood is “type A” have A extensions on their blood cells. It is also possible to have only B extensions (and be type B); to have both A and B extensions (and be type AB); or to have none of these extensions (and be type O). Note that a person whose genotype is AO is phenotypically type A; likewise, a person whose genotype is BO is phenotypically type B.

Table 11.3

Why are people with **type O** blood considered "universal donors"? Why are those with **type AB** considered "universal acceptors"?

THE SCIENCE BEHIND BLOOD DONATION

BLOOD TYPE	CAN DONATE TO	CAN RECEIVE FROM
Type A • Has A antigens • Produces antibodies that attack B antigens	Type A, Type AB	Type A, Type O
Type B • Has B antigens • Produces antibodies that attack A antigens	Type B, Type AB	Type B, Type O
Type AB • Has A and B antigens • Produces neither A nor B antibodies • Universal recipient	Type AB	Type A, Type B, Type AB, Type O
Type O • Has neither A nor B antigens • Produces antibodies that attack A and B antigens • Universal donor	Type A, Type B, Type AB, Type O	Type O

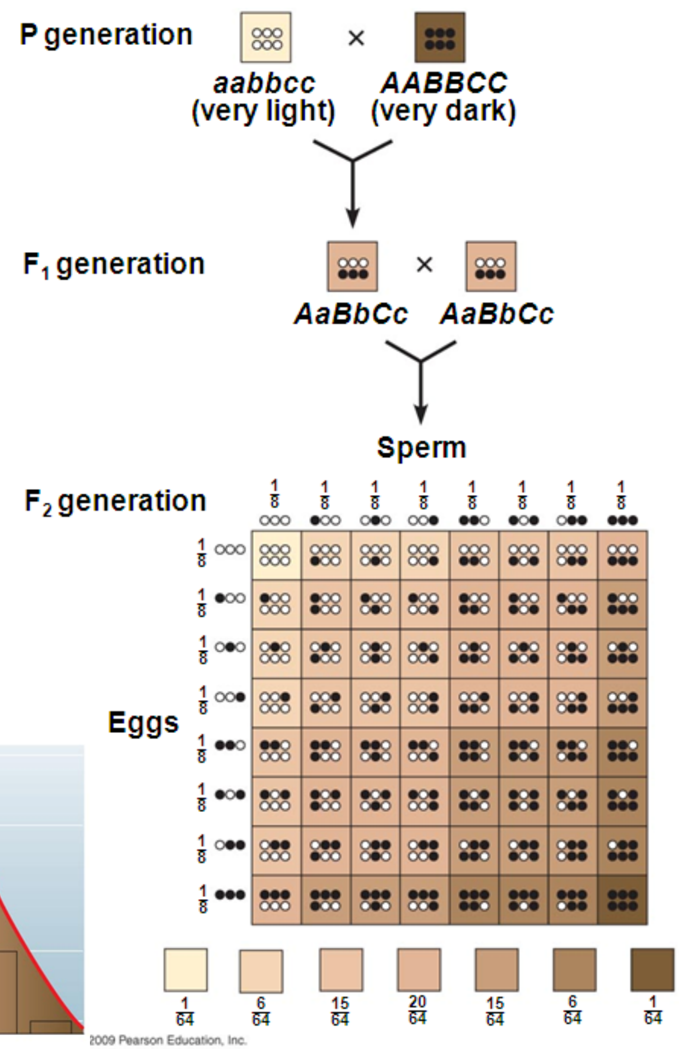
Individuals with type O blood are universal donors. Individuals with type AB are universal recipients.

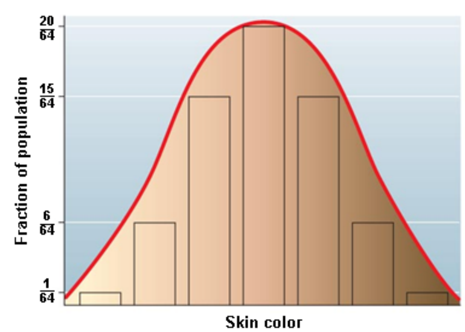
Figure 7-21
What Is Life? A Guide To Biology

Variations on Mendel's rules of genetics – **Polygenic traits**

- Traits that are controlled by more than one gene
- Additive effects of all the genes together produce a continuum of phenotypes

Figure 7-22
What Is Life? A Guide To Biology, Second Edition





Variations on Mendel's rules of genetics – **Pleiotropy**

- Individual genes can influence multiple traits (phenotypes)
- Ex: Hemoglobin gene in red blood cells has multiple effects on health and function

What is the benefit of "almost" having sickle cell disease?

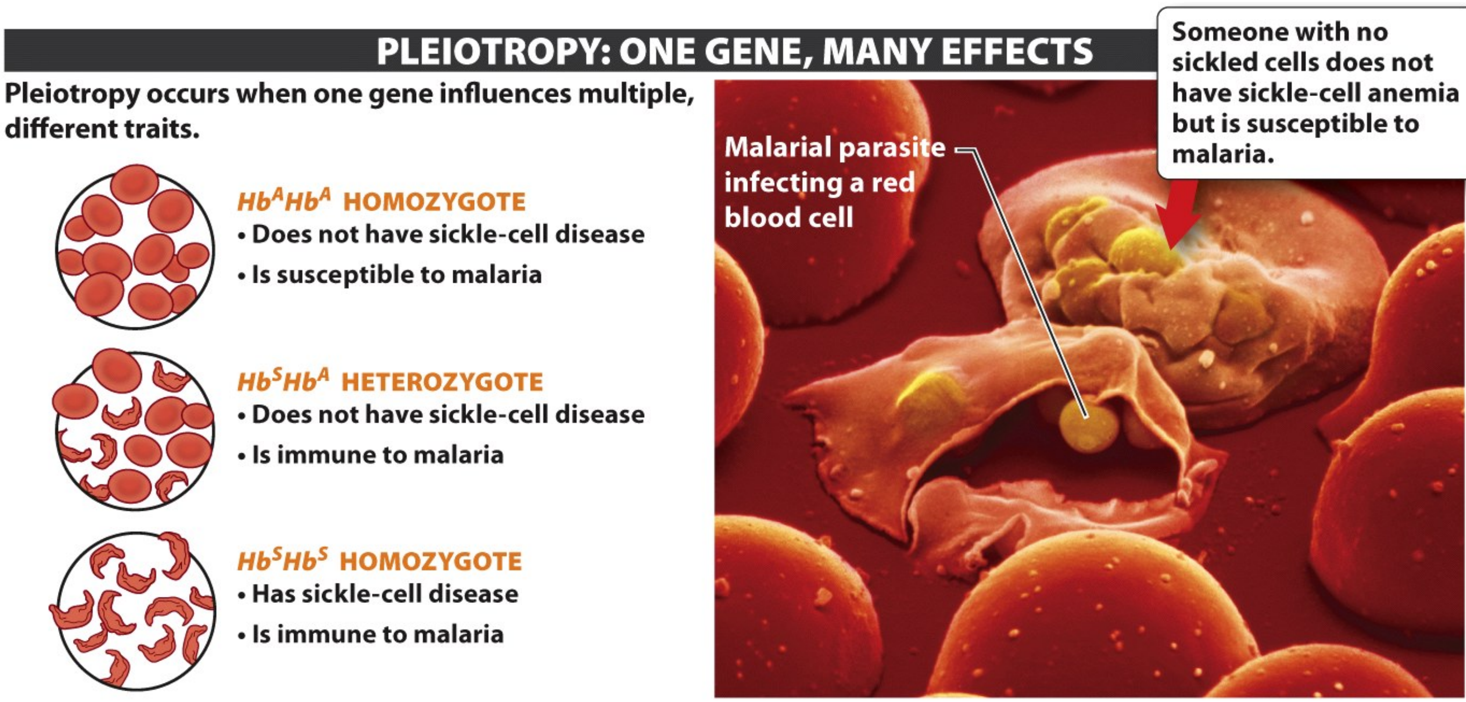


Figure 7-23
***What Is Life? A Guide To Biology*, Second Edition**

Variations on Mendel's rules of genetics – **The role of the Environment**

Figure 7-26
What Is Life? A Guide To Biology, Second Edition

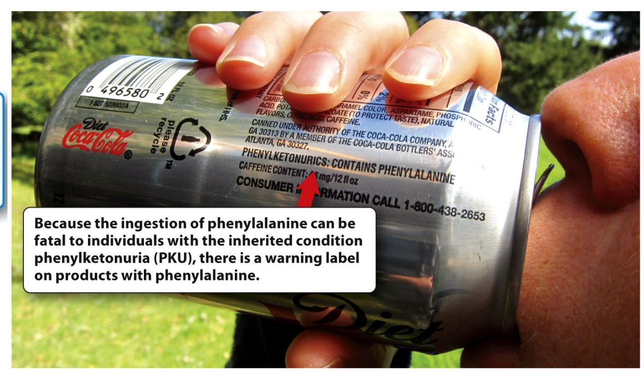


Figure 7-25
What Is Life? A Guide To Biology, Second Edition

- The environment can influence how and if genes are expressed
- Environment can be changed to offset the effect of genes
- More the rule than an exception

Variations on Mendel's rules of genetics – **Linked genes**

Figure 7-28
What Is Life? A Guide To Biology, Second Edition

- Genes on the same chromosome are usually inherited together (chromosomes are packaged into gametes)

- Exception: Crossing over

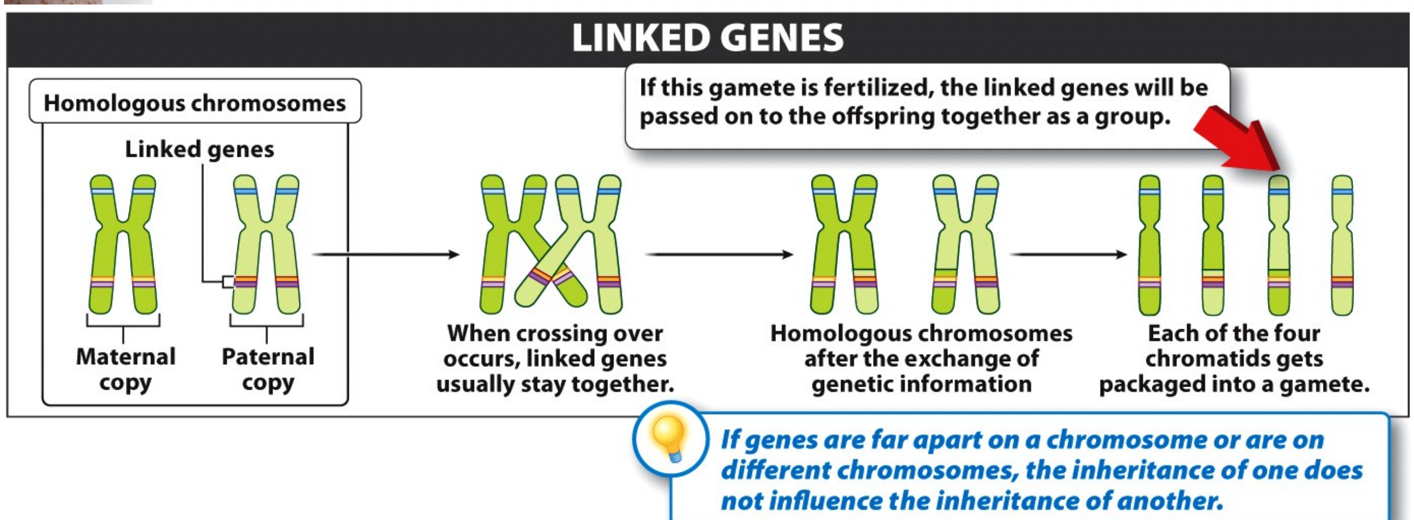


Figure 7-29
What Is Life? A Guide To Biology

Variations on Mendel's rules of genetics – **Sex-linked traits**

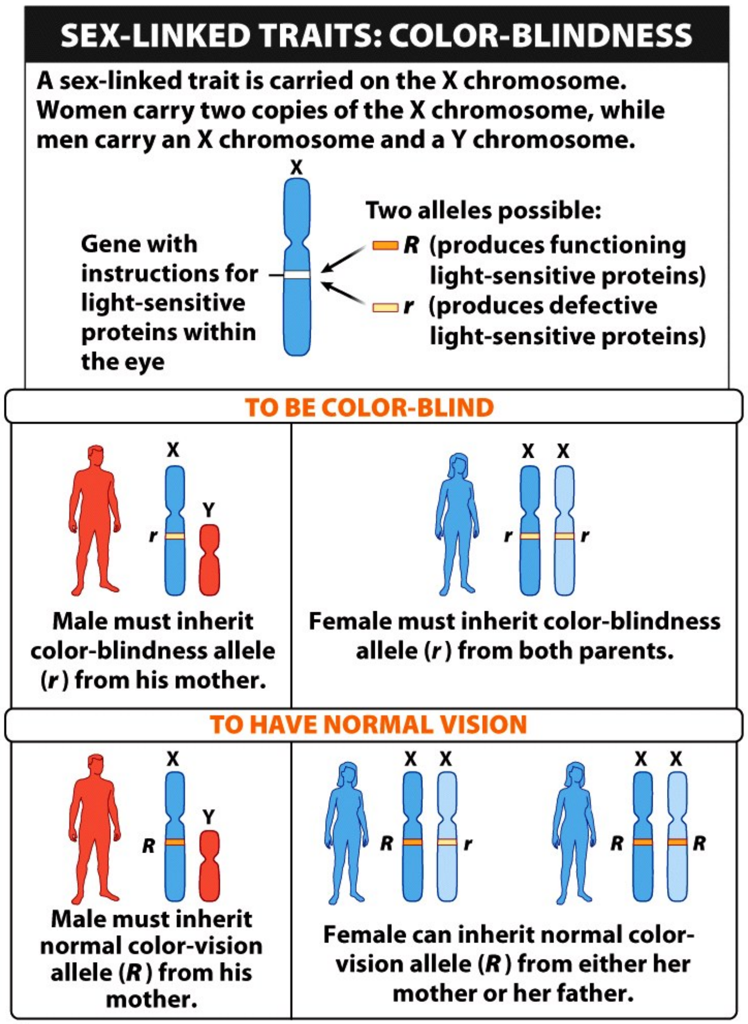
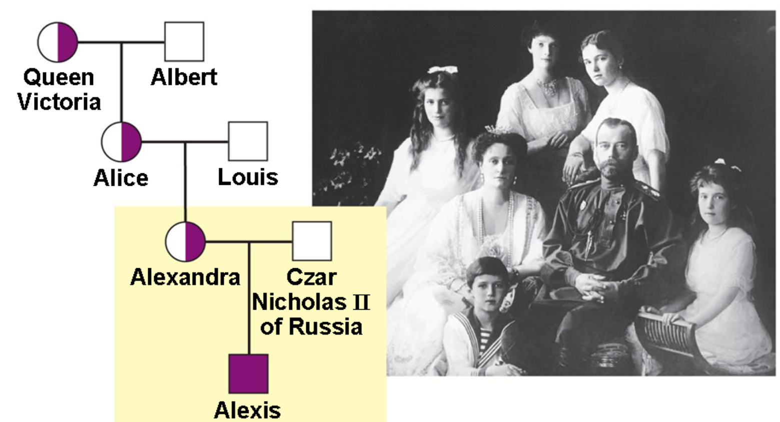


Figure 7-24
What Is Life? A Guide To Biology

- X chromosome has many more genes than the Y chromosome
- Females have two Xs and males only have one X
- Sex-linked disorders usually affect males and not females (however, females can be **carriers**)



X-linked Inheritance

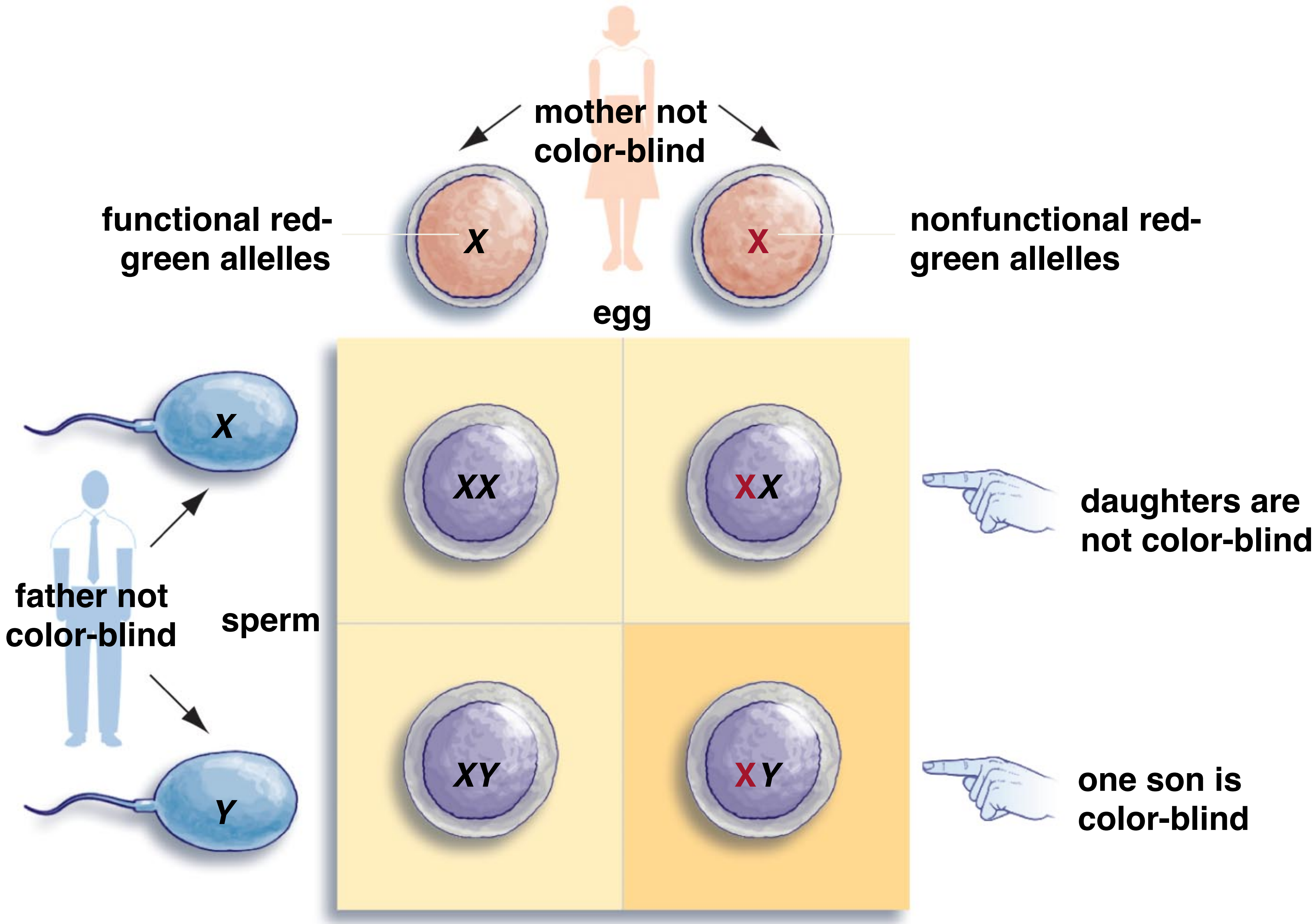


Figure 12.2

Hemophilia is a blood-clotting disorder caused by a defective recessive gene on the X chromosome.

If a mother is a carrier for hemophilia (X^NX^n), and a father is not affected (YX^N), what is the chance that they will have a baby with hemophilia?

Summary

- Modern genetics began with Gregor Mendel's pea plant experiments
- Alleles are different forms of a gene, and are generally either dominant or recessive
- Offspring have two alleles for every gene – one from each parent (homozygous vs. heterozygous)
- Mendel's rules include the Law of segregation and the Law of independent assortment
- Variation on Mendel's rules include incomplete dominance, multiple alleles, codominance, polygenic traits, pleiotropy the role of the environment, linked genes, and sex-linked traits

By the end of this chapter, you should be able to:

1) Describe Gregor Mendel's inheritance experiments involving pea plants
2) List and describe Mendel's three hypotheses of inheritance
3) Define the Law of segregation and the Law of independent assortment
4) Utilize pedigrees and punnett squares to identify individuals and to determine genotypic and phenotypic probabilities
5) Describe the role of carriers in autosomal and sex-linked disorders
6) Describe the variations on Mendel's laws and be able to utilize these concepts in genetics problems