Go to the "Slide Show" shade above

Click on "Play from Beginning"

Inheritance Patterns

Chapter 13

WARM-UP

Mendel's LAW OF ? describes the Inheritance of a Single Character.

- If the alleles of an inherited pair differ, then one determines the organism's appearance and is called the **? Allele**.
- The other has no noticeable effect on the organism's appearance and is called the **? Allele**.
  - The **?** is the appearance or expression of a trait.
  - The **?** is the genetic makeup of a trait.
  - The **same ?** (appearance) may be determined by **more than one ?**.

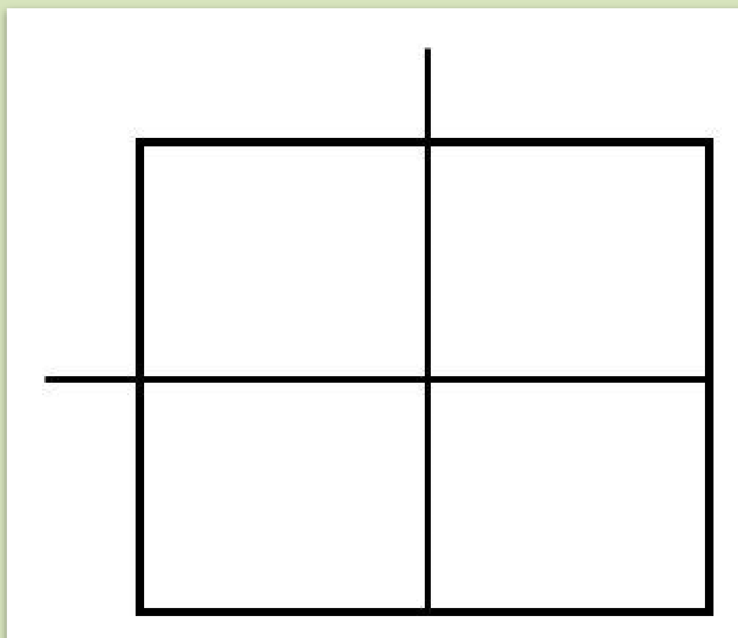
WARM-UP

Mendel's LAW OF SEGREGATION describes the Inheritance of a Single Character.

- If the alleles of an inherited pair differ, then one determines the organism's appearance and is called the **Dominant Allele**.
- The other has no noticeable effect on the organism's appearance and is called the **Recessive Allele**.
  - The **Phenotype** is the appearance or expression of a trait.
  - The **Genotype** is the genetic makeup of a trait.
  - The **same phenotype** (appearance) may be determined by **more than one genotype**.

Using Probability and ? Squares to Work Genetics Problems

A homozygous tall pea plant (TT) is crossed with a homozygous short pea plant (tt). Use the law of **?** to perform the Punnett square of the F_1 generation.



F_2 Generation

Phenotype:

Genotype:

Using Probability and ? Squares to Work Genetics Problems

A homozygous tall pea plant (TT) is crossed with a homozygous short pea plant (tt). Use the law of **segregation** to perform the Punnett square of the F_1 generation (**both F_1 parents are Tt**).

F_1 Generation
Sperm + egg → zygote
Tt Tt → F_2

WARM-UP

	T	t
T	TT	Tt
t	Tt	tt

F_2 Generation

Phenotype:

75% Tall
25% Short

Genotype:

25% Homozygous Tall
50% Heterozygous Tall
25% Homozygous Short

The LAW OF ? ? is revealed by tracking 2 Characters at once.

- A **? Cross** is a mating of parental varieties that differ in ? characters.
- Mendel performed the following dihybrid cross with the following results:
  - **? Generation**: round yellow seeds × wrinkled green seeds
  - **? Generation**: all plants with round yellow seeds
  - **? Generation**:
    - **?/16** had round yellow seeds
    - **?/16** had wrinkled yellow seeds
    - **?/16** had round green seeds
    - **?/16** had wrinkled green seeds

WARM-UP

The LAW OF INDEPENDENT ASSORTMENT is revealed by tracking Two Characters at once

- A **Dihybrid Cross** is a mating of parental varieties that differ in two characters.
- Mendel performed the following dihybrid cross with the following results:
  - **P Generation**: round yellow seeds × wrinkled green seeds
  - **F_1 Generation**: all plants with round yellow seeds
  - **F_2 Generation**:
    - **9/16** had round yellow seeds
    - **3/16** had wrinkled yellow seeds
    - **3/16** had round green seeds
    - **1/16** had wrinkled green seeds

Lesson Objectives

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

- Define inheritance patterns that yield non-Mendelian dominance.
- Describe incomplete dominance (blending) with examples.
- Understand multiple alleles in terms of codominance and explain (map out) human blood typing, donors, recipients.
- Understand sex determination, sex-linked traits & disorders.
- Understand Polygenic Inheritance causing Continuous Variation, giving examples.
- Explain Epistasis (gene modification).
- **Science Practice: Build a Body & Blood Type Labs**

Inheritance Patterns

- Ways in which traits (genes) are inherited from generation to generation.
- So far we have been discussing the traits controlled by **one gene** with only **two alleles** that are transmitted in a **simple dominant/recessive** nature.
- There are many relationships which alleles can exhibit in nature that are **NOT** of a dominant/recessive nature.

There are exceptions to Mendel's principles. Not all genes show a pattern of dominance and recessiveness.

For some genes, there are more than two alleles.

Many times, traits are controlled by more than one gene.

Inheritance Patterns

- Incomplete "Intermediate" Dominance
- Multiple Alleles and Codominance
- Sex Determination & Sex-Linked Genes
- Polygenic Inheritance causing Continuous Variation
- Epistasis

Incomplete Dominance

✓Occurs when there are no forms of the gene that are dominant.

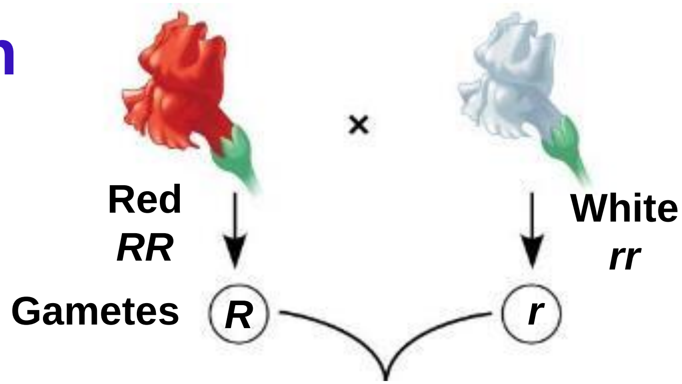
✓F1 hybrids have an appearance somewhat **in-between** the **phenotypes** of the two parental varieties.

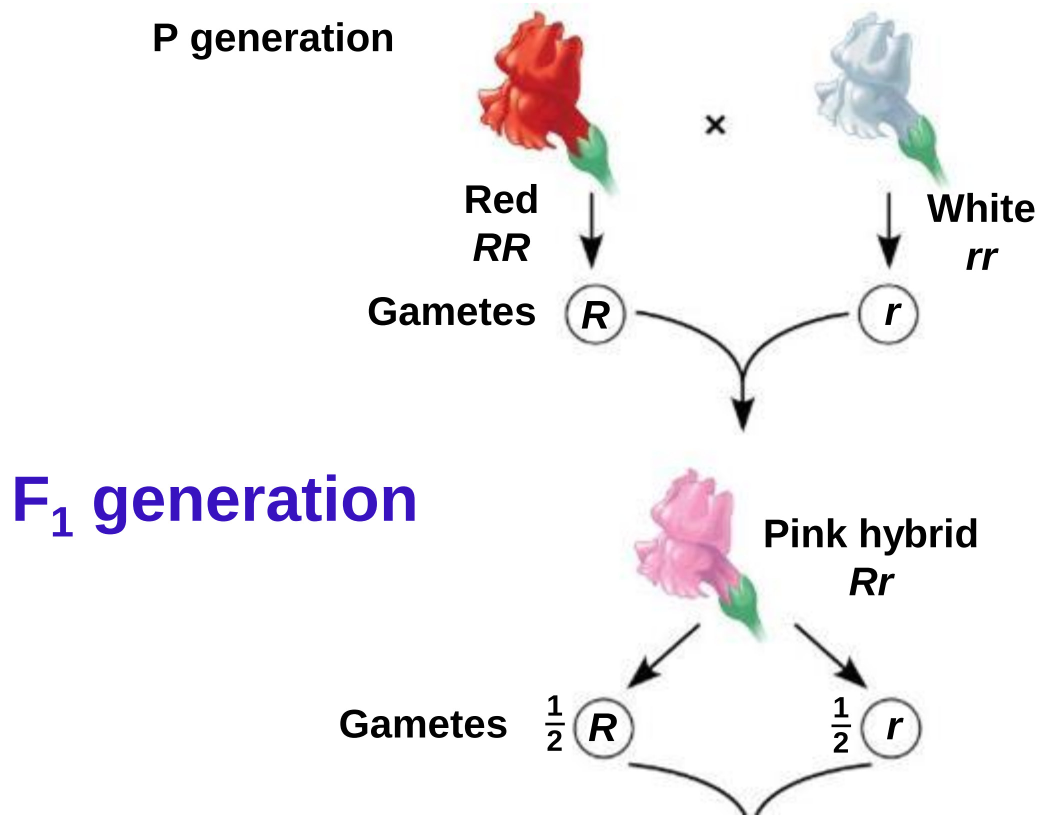
✓The resulting trait is a **BLEND** of the two parental traits.

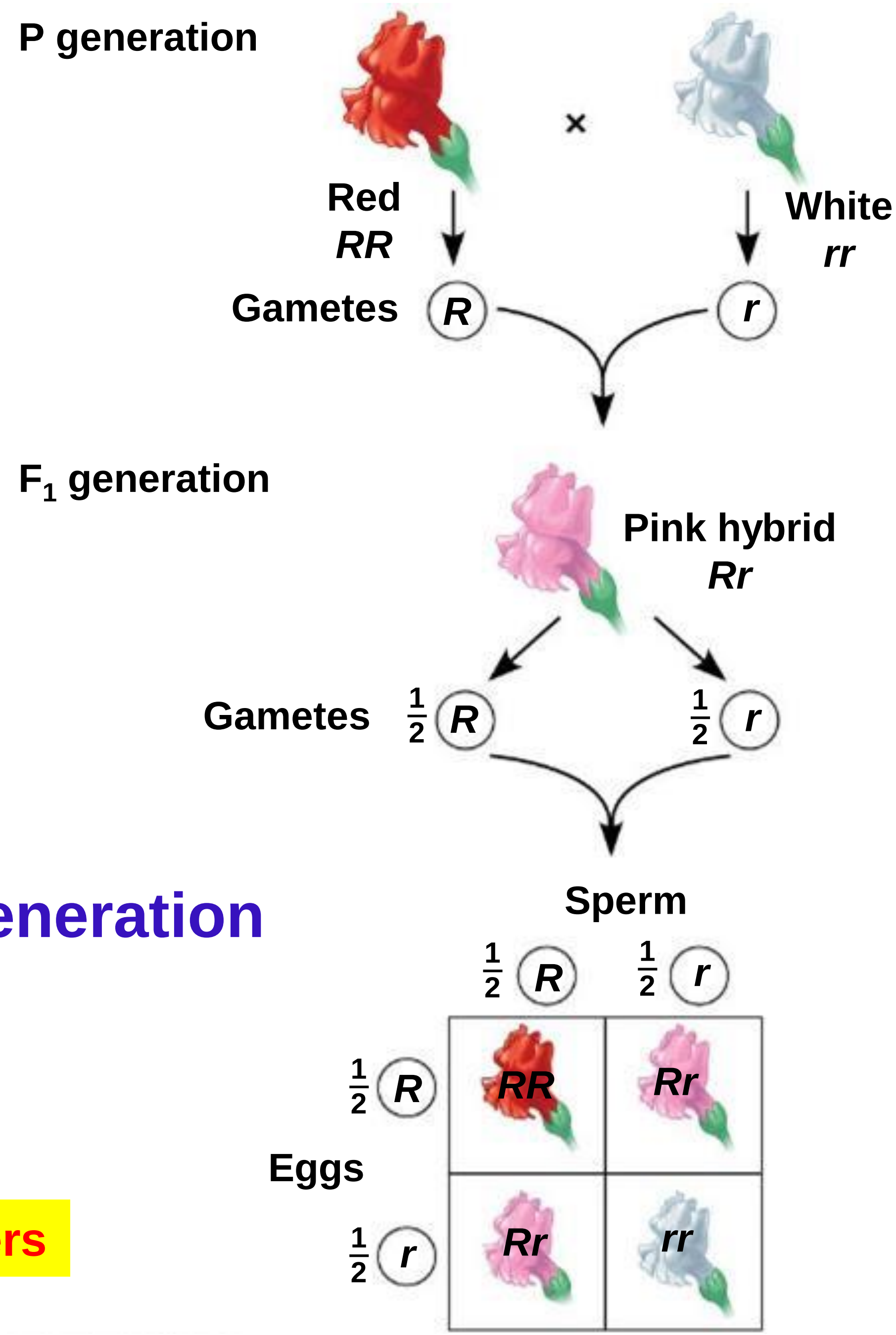
+

=

P generation




P generation
×
Red
RR
White
rr
Gametes
R
r
F1 generation
Pink hybrid
Rr
Gametes
1/2 R
1/2 r

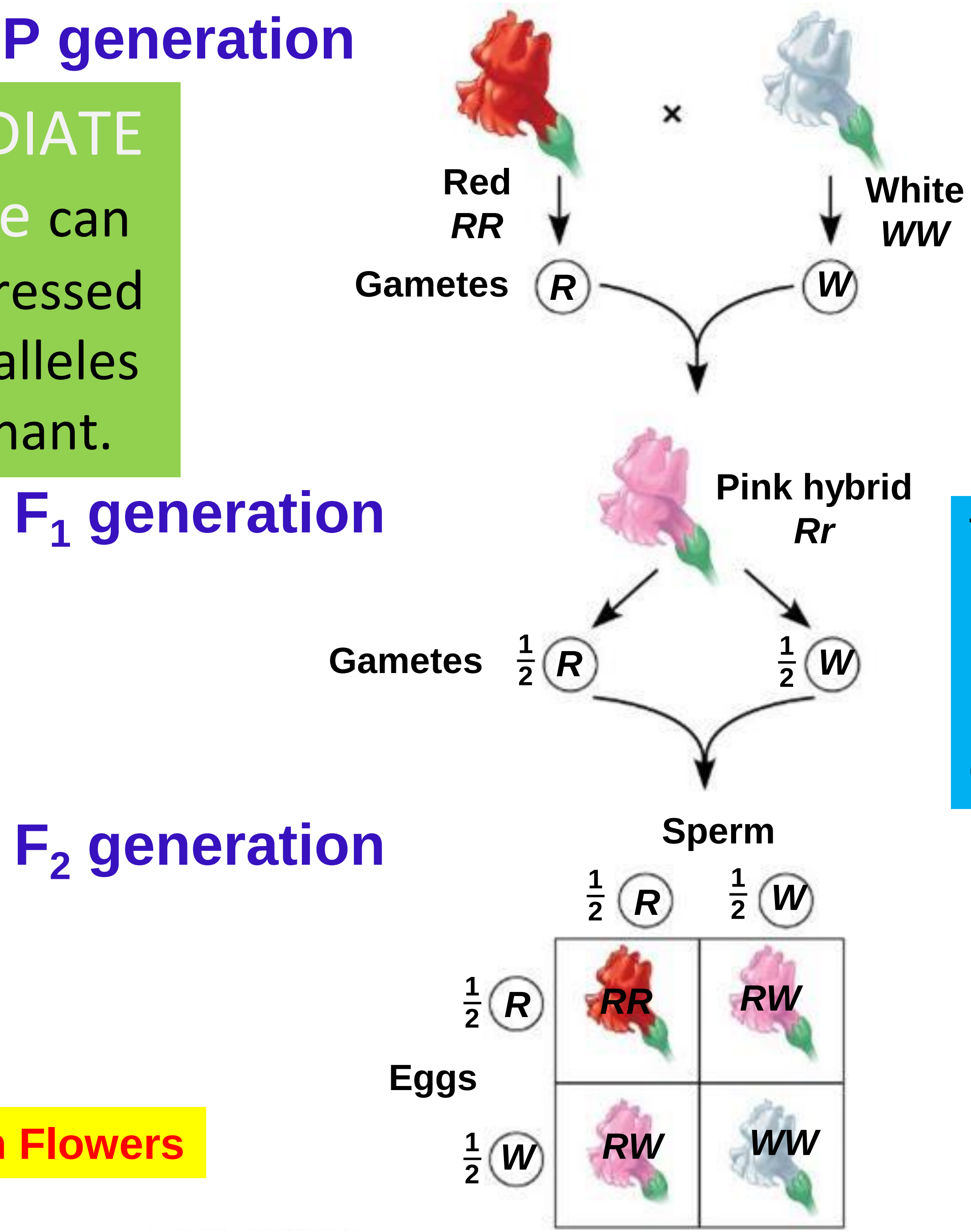


F_2 generation

Snapdragon Flowers

P generation

INTERMEDIATE dominance can also be expressed with BOTH alleles being dominant.



The HETEROZYGOUS individuals show the intermediate effects of both alleles.

Snapdragon Flowers

Incomplete Dominance

Blending Inheritance, Co-Dominance Inheritance, Intermediate Dominance

- The phenotype ratios and genotype ratios are always the same.
- One can always tell that blending is involved if there are TWO EXTREMES and a "BLENDING" intermediate of these two extremes to make up the third characteristics.
- If a phenotype shows 3 traits, it involves blending.
  - Type of inheritance in which the HETEROZYGOUS individuals show the effects of both alleles.

Multiple Alleles: Many Genes have more than Two Alleles in the Population

- Although each individual carries, at most, two different alleles for a particular gene, in cases of **Multiple Alleles**, more than two possible alleles exist in a **Population**.
- Human **ABO Blood Group** phenotypes involve **three alleles for a single gene (in the same locus)**.
- The four human blood groups**, A, B, AB, and O**, result from combinations of these three alleles.
- The **A and B alleles** are both expressed in **heterozygous** individuals, making both alleles **Codominant**.

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

I^A	**I = immunoglobulin (protein)** on the Red Blood Cell; **"A" is a polysaccharide**

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

I^A	**I = immunoglobulin (protein)** on the Red Blood Cell; **"A" is a polysaccharide**
I^B	"B" is a polysaccharide on the immunoglobulin

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

I^A	**I = immunoglobulin (protein)** on the Red Blood Cell; **"A" is a polysaccharide**
I^B	"B" is a polysaccharide on the immunoglobulin
i	Neither polysaccharide ("A" or "B") is present on the immunoglobulin of the red blood cell

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

Blood Types and possible genotypes

Blood Type	Possible Genotype
A	$I^A I^A$ or $I^A i$

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

Blood Types and possible genotypes

Blood Type	Possible Genotype
A	$I^A I^A$ or $I^A i$
B	$I^B I^B$ or $I^B i$

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

Blood Types and possible genotypes

Blood Type	Possible Genotype
A	$I^A I^A$ or $I^A i$
B	$I^B I^B$ or $I^B i$
AB	$I^A I^B$

Multiple Alleles

HUMAN **ABO** BLOOD TYPING

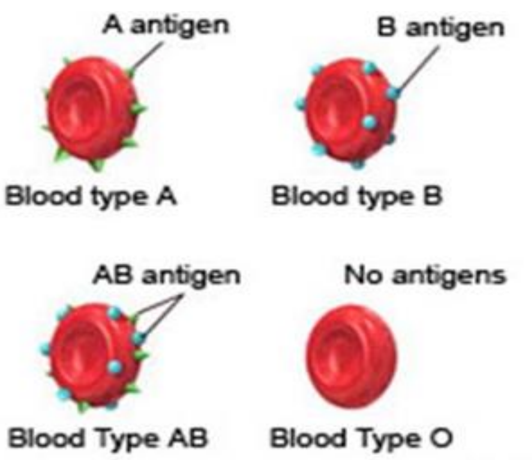
Blood Types and possible genotypes

Blood Type	Possible Genotype
A	$I^A I^A$ or $I^A i$
B	$I^B I^B$ or $I^B i$
AB	$I^A I^B$
O	$i\ i$

Dear Abby - YOU DECIDE THE SOLUTION SCIENTIFICALLY

QUICK CHECK

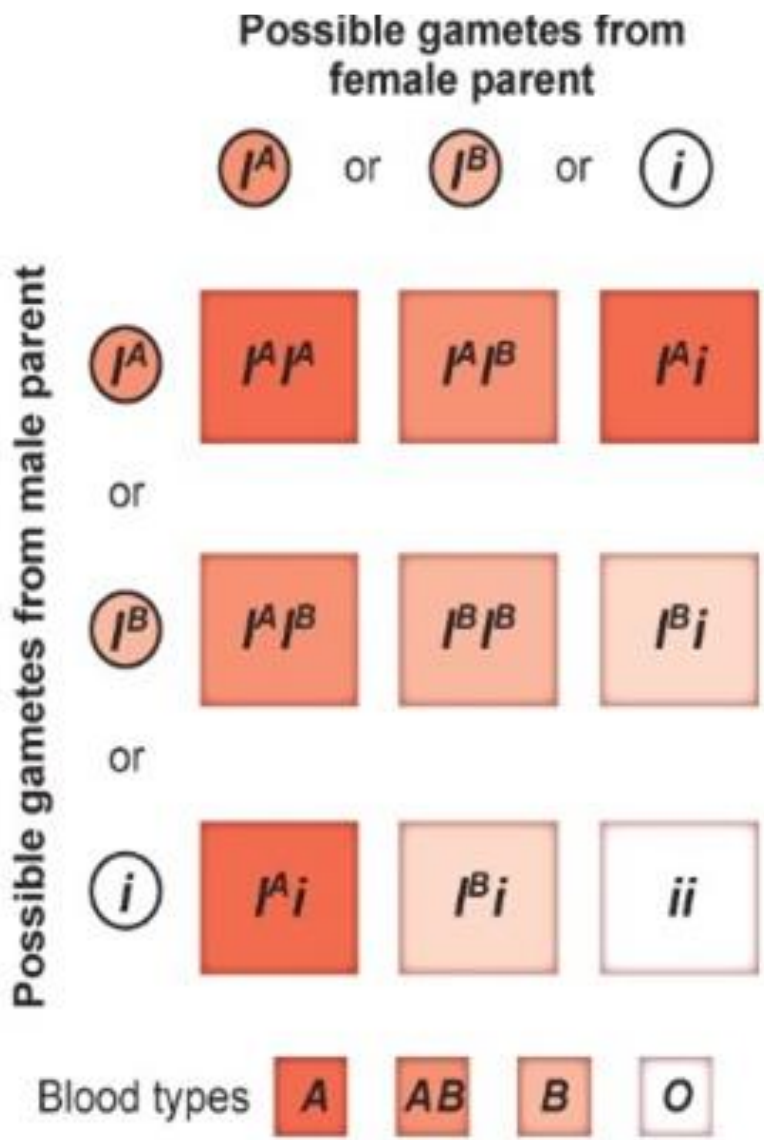
- "I discovered quite by accident that one of my children has an entirely different blood type than mine. I made some inquiries and have been informed it is not possible for me to be this boy's father. Obviously my wife has been unfaithful to me. After more than 12 years of a fairly happy marriage, I am at a loss as to what I should do. Should I confront my wife with this and demand she tell me the whole story? Or since there is nothing I can do about it now, should I keep my mouth shut and try to live with this very disturbing knowledge? SHOCKED & UNDECIDED"



Dear Shocked,

You have been misinformed. It IS possible for a child to have an entirely different blood type than the father. So unless you have more conclusive evidence to support your suspicions, the word from here is "cool it, dad."

Complex Patterns of Inheritance



Multiple Alleles

- Blood groups in humans
- ABO blood groups have three forms of alleles.

Genetics of the ABO System

A person with blood type A will produce the A antigen (polysaccharide).

The body produces antibodies against antigen B (polysaccharide).

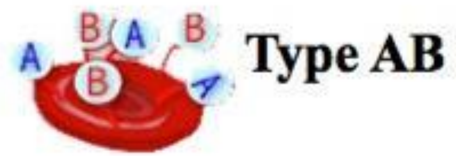
Genetics of the ABO System

A person with blood type B will produce the B antigen (polysaccharide).

The body produces antibodies against antigen A (polysaccharide).

Genetics of the ABO System

A person with blood type AB will produce both antigen A and antigen B (different polysaccharides).



The body does NOT produce antibodies against either antigen A and antigen B (Polysaccharides).

Genetics of the ABO System

A person with blood type O will produce NEITHER antigen A or antigen B (polysaccharides).

Type O

The body produces antibodies against both antigen A and antigen B (Polysaccharides).

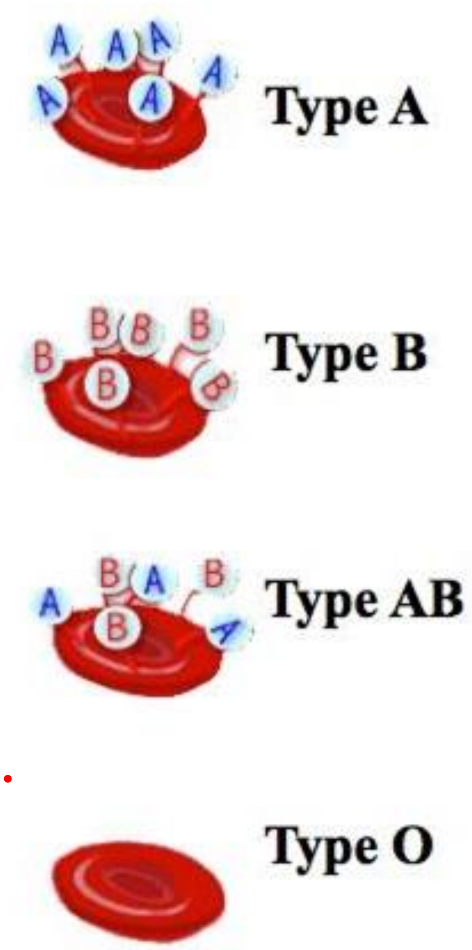
Genetics of the ABO System

A person with blood type A will produce the A antigen (polysaccharide).
The body produces antibodies against antigen B (polysaccharide).

A person with blood type B will produce the B antigen (polysaccharide).
The body produces antibodies against antigen A (polysaccharide).

A person with blood type AB will produce both antigen A and antigen B (different polysaccharides).
The body does NOT produce antibodies against either antigen A and antigen B (Polysaccharides).

A person with blood type O will produce NEITHER antigen A or antigen B (polysaccharides).
The body produces antibodies against both antigen A and antigen B (Polysaccharides).



Antibodies

- Our bodies possess antibodies which fight “foreign” substances called “**antigens**”.
- **Polysaccharides A** and **B** are considered foreign substances (antigens) in a different person.
- Typing Blood is extremely important when receiving blood from others.
- Antibodies will cause agglutination in the blood when the polysaccharide is attacked by the antibody.

Person with Blood Type:	Produces Antibodies Against
A	B
B	A
O	A, B
AB	none

TRY IT

Blood Donation and Receiving

Complete the Table of possible recipients and donors for a "blood bank"

Recipient	Donors
A	?
B	?
O	?
AB	?

Why do vampires stop work at midnight?
[To take a coffin break]

TRY IT

Blood Donation and Receiving

Table of possible recipients and donors for a "blood bank"

Recipient	Donors
A	A, O
B	B, O
O	O
AB	AB, A, B, O

- **A person with blood type O is a universal donor (can donate to any blood type) because type O forms antibodies against type A & B, *but does not have any antigens for others to attack*.**

- **A person with blood type AB is a universal recipient (can receive any blood type) because type AB forms NO antibodies.**

Multiple Alleles

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

Multiple Alleles

QUICK CHECK

Charlie Chaplin (*world famous comedian in original movies*) was accused of being a child's father in Court (1940).

Blood Type	
O	Chapman
A	Mother
B	Child

?

Multiple Alleles

QUICK CHECK

Charlie Chaplin (world famous comedian in original movies) was accused of being a child's father in Court (1940).

Blood Type	
O	Chapman
A	Mother
B	Child

NOT possible!

	I^A	I^A
i	I^Ai	I^Ai
i	I^Ai	I^Ai

	I^A	i
i	I^Ai	ii
i	I^Ai	ii

QUICK CHECK

Multiple Alleles

If a boy has a blood type O and his sister has blood type AB, what are the genotypes and phenotypes of their parents?

Boy - type O (ii)

X

Girl - type AB (I^AI^B)

QUICK CHECK

Multiple Alleles

Answer:

	I^A	i
I^B	I^AI^B	
i		ii

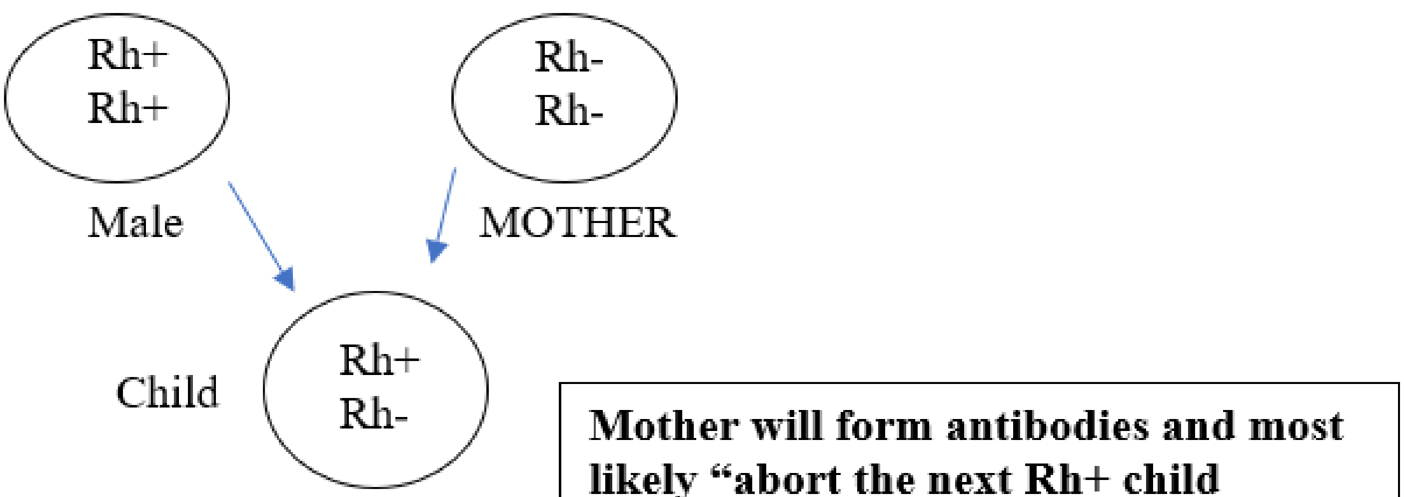
Parents:

genotypes = I^Ai and I^Bi

phenotypes = A and B

Rh Factor

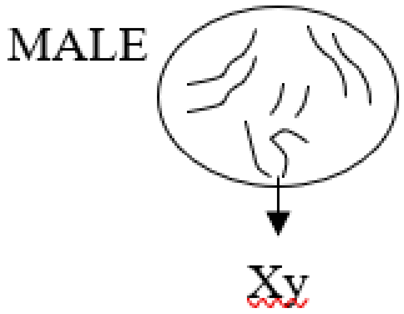
- There is another factor to consider, however (*Rh factor*).
- **Blood type is actually given as: O+, O-, A+, A-, B+, B-, AB+, AB-.**
- Discovered first in the Rhesus monkey, hence "Rh" factor.
- **Mothers can form antibodies against the "Rh factor" after having a child with the factor.**
- Two alleles: **Rh+** has the factor, **Rh-** does not have the factor.

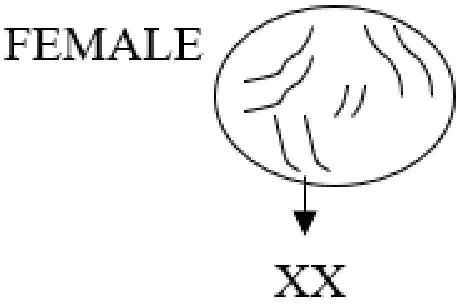


Sex Determination

1. The determination of sex is due to an accumulation of a number of genes located on Sex Chromosome.

2. Sex determination was first discovered in Fruit Flies (*Drosophila melanogaster*).





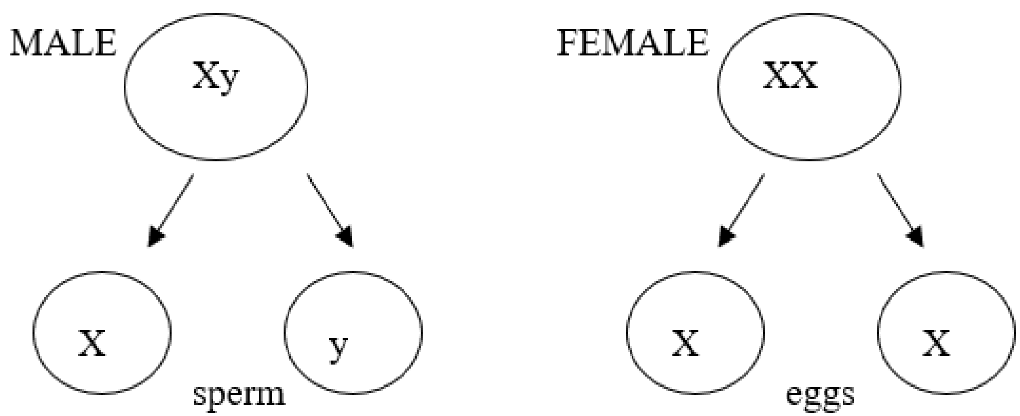
Sex Determination

1. Body cells vs. gametes in humans
   - 22 homologous pairs of **autosomes** (44 chromosomes) – *determine non-sex related traits*
   - 1 homologous pair of **sex chromosomes** (2 chromosomes) – *determine sex related traits*
2. Gametes
   - haploid chromosome number (23 chromosomes)
   - sex is determined by the sex chromosomes

Sex Determination

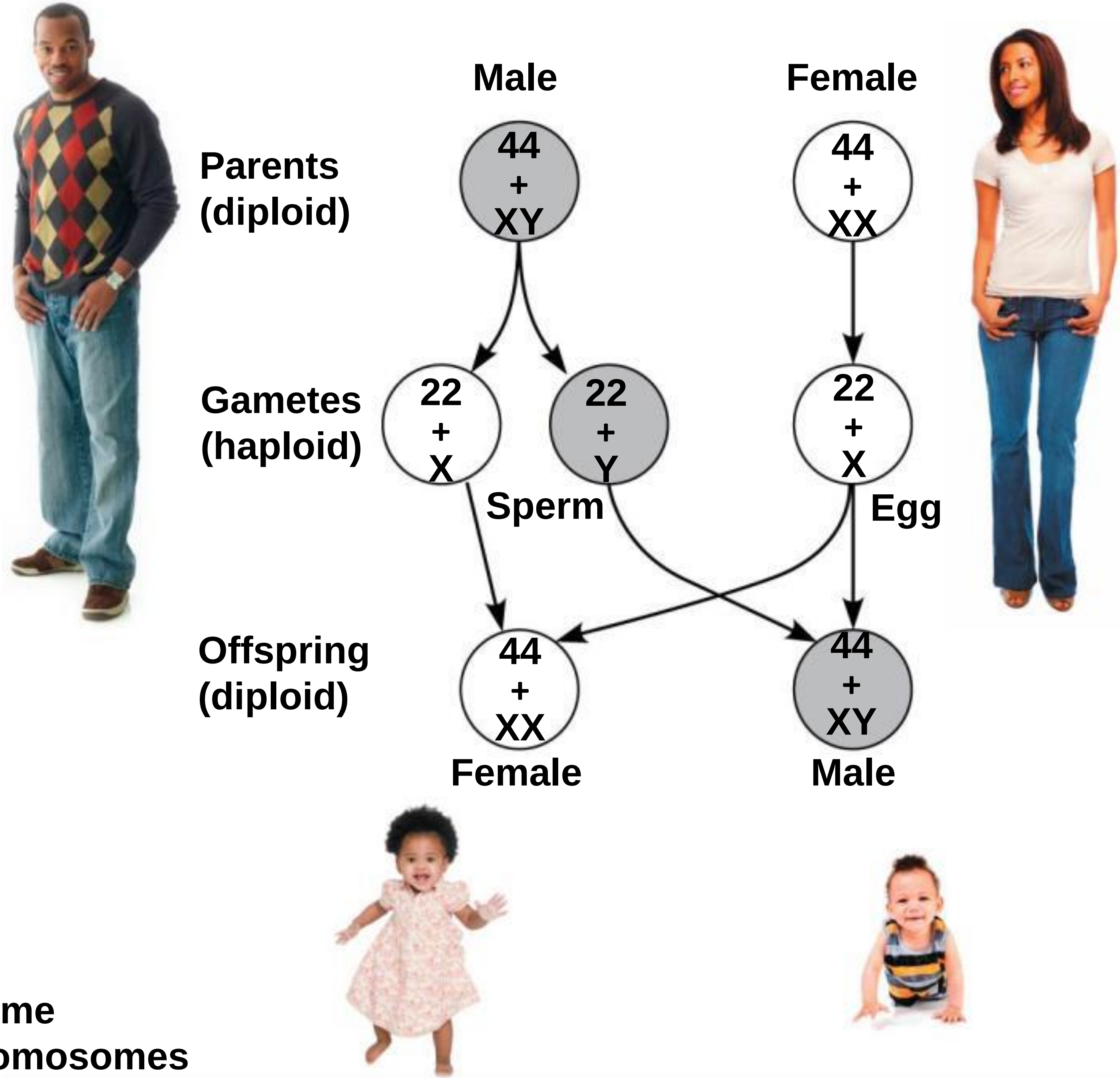
The sex of the offspring is determined by the MALE gametes:

- Sperm has TWO kinds of chromosome possibilities (X and y).
- Eggs have only ONE kind of chromosome (X).



	X	Y
X	XX	Xy
X	XX	Xy

50% XX → female
50% Xy → male



44 autosome
2 sex chromosomes

Sex-Linked Genes

- Traits that are inherited directly based on the **sex chromosomes** not on the autosomes.
- Traits are most commonly carried on the **X chromosome**.
- **Sex-Linked Traits** – carried only on the non-homologous portion of the X chromosome (*where there is no matching allele in the y chromosome for the male*).
- Where ever there is a sex-linked trait, males always possess it, but females must be homozygous recessive to show the trait.

Sex-Linked Genes

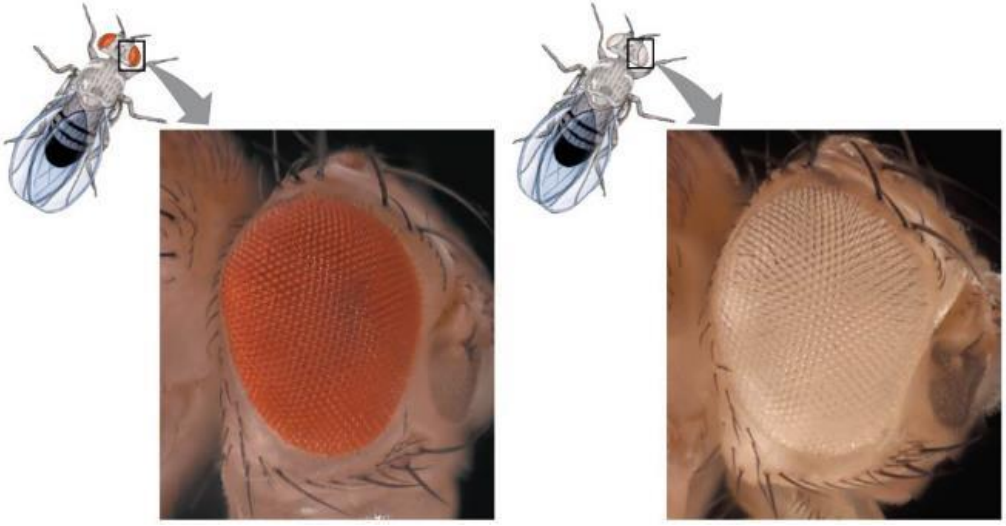
- The Y chromosome has very little genetic information and therefore, carries very little sex-linkage.
- **Holandric Traits** – carried only on the y chromosome and therefore only appears in males.

- Hypertrichosis pinnae - causes excessive hair in the ear.
- Male infertility - males can't produce offspring.
- *Retinitous pigmentosa* - causes gradual decline in vision.
- Color blindness - inability to see some color or color differences.

Sex-Linked Genes exhibit a unique pattern of inheritance

- **Sex-Linked Genes** are located on either of the sex chromosomes.
- All the other chromosomes (autosomes) are present but do not affect the transmission of the trait.
- Example: White eye color in the fruit fly is an

  X-linked recessive trait



Sex-Linked Genes

Eye color in fruit flies

$X^R X^R$

Homozygous Red-eyed female

$X^R X^r$

Heterozygous Red-eyed female

$X^r X^r$

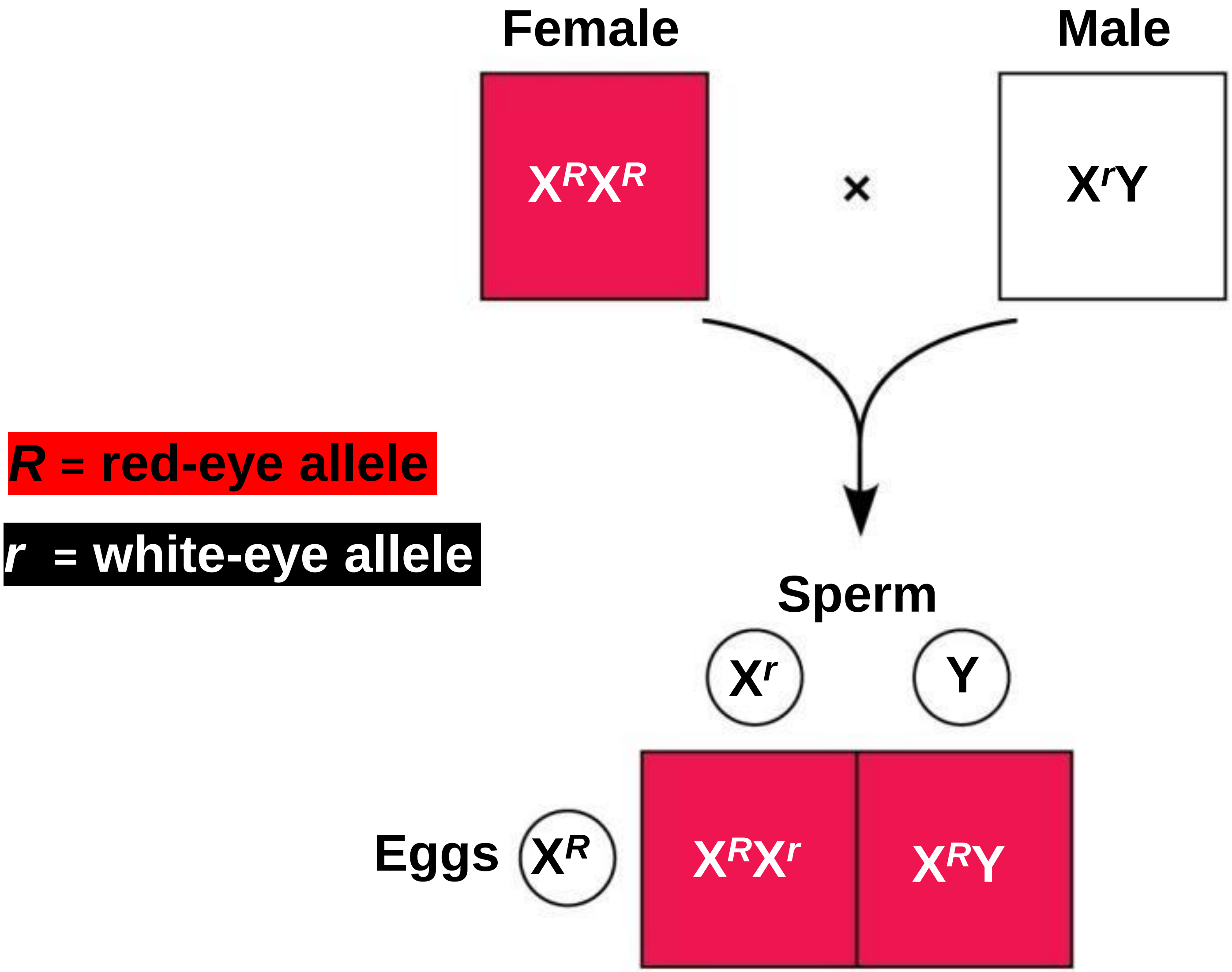
Homozygous White-eyed female

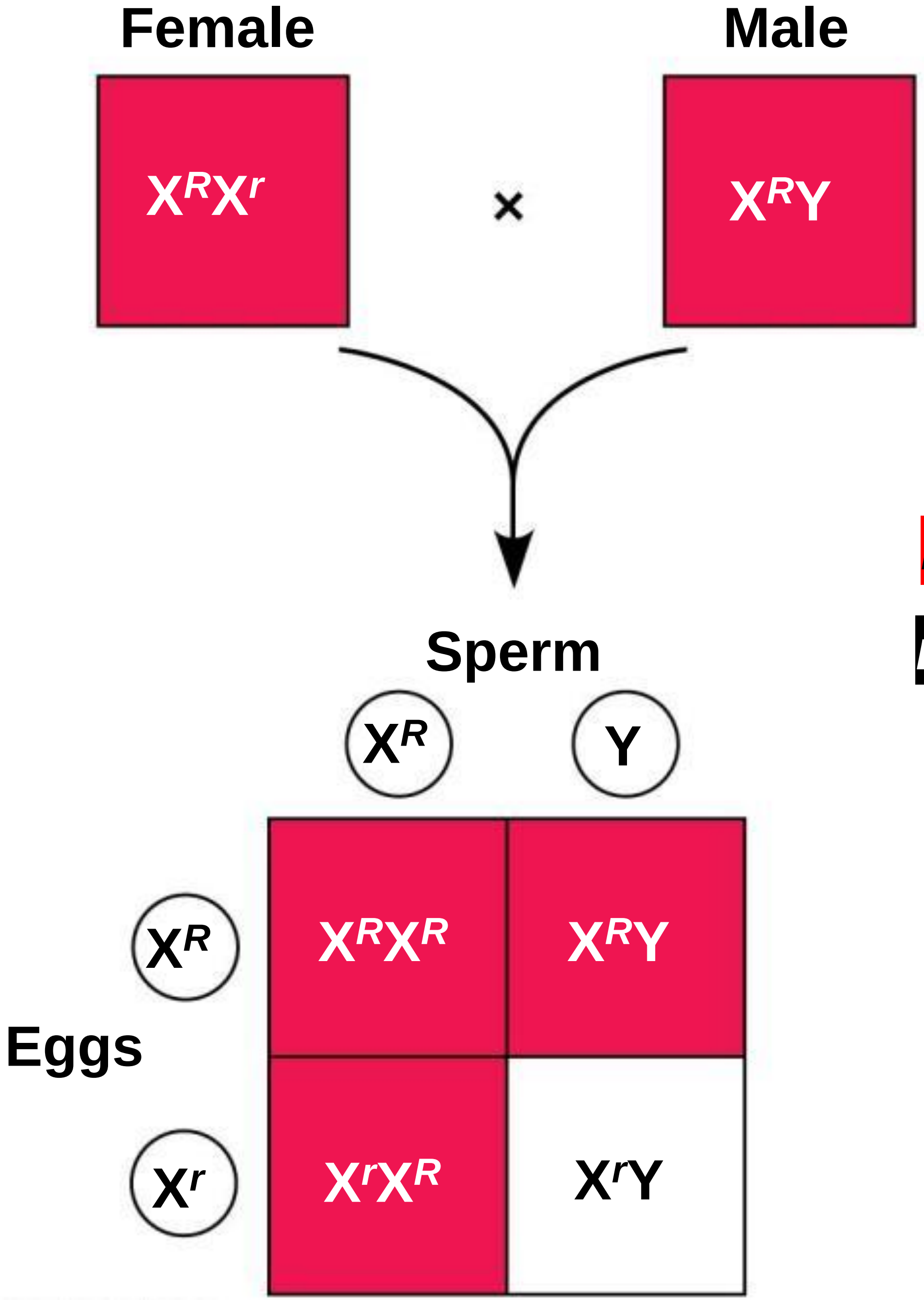
$X^R y$

Red-eyed male

$X^r y$

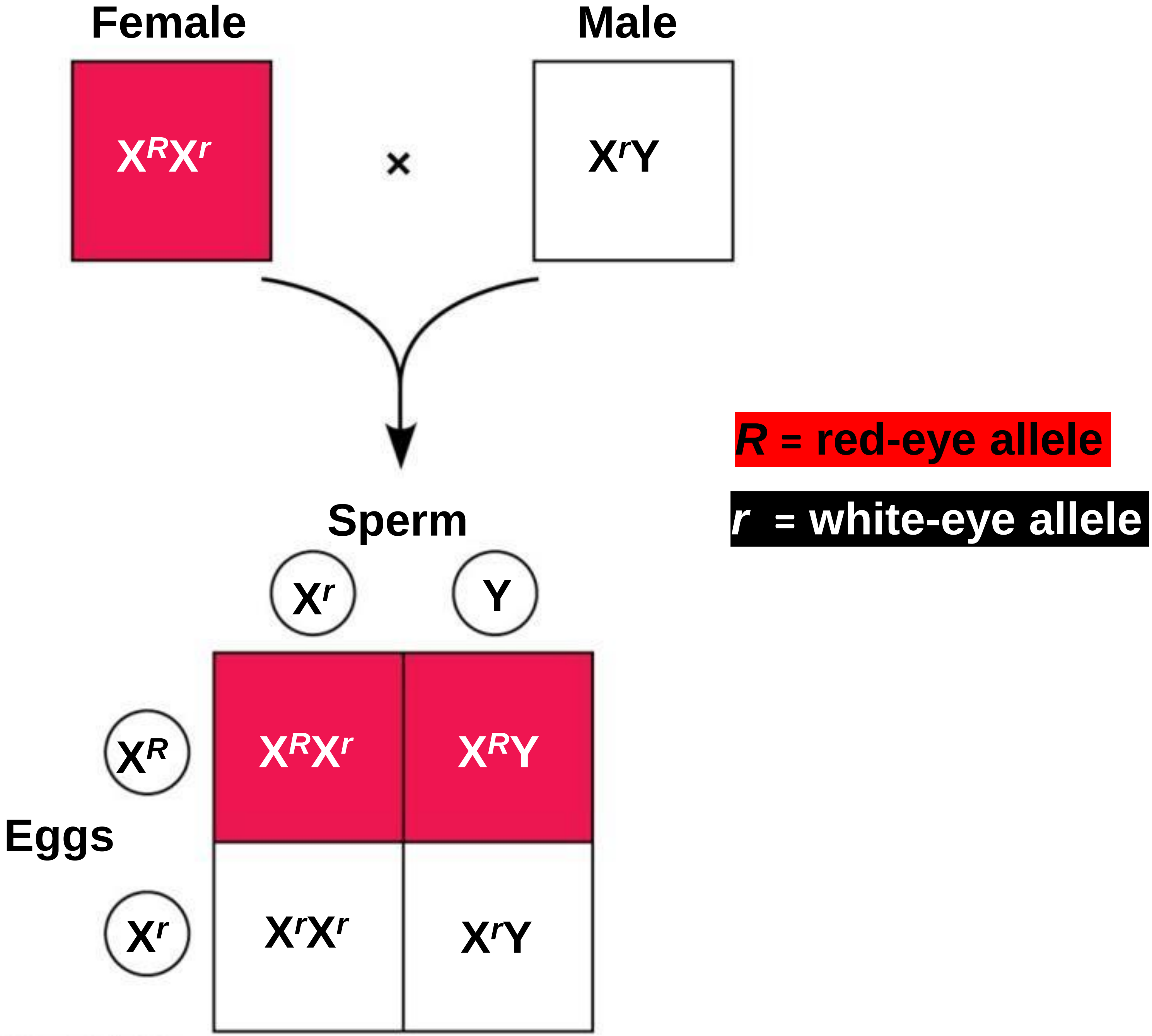
White-eyed male


Female
Male
X^RX^R
×
X^rY
R = red-eye allele
r = white-eye allele
Sperm
X^r
Y
Eggs
X^R
X^RX^r
X^RY



R = red-eye allele

r = white-eye allele

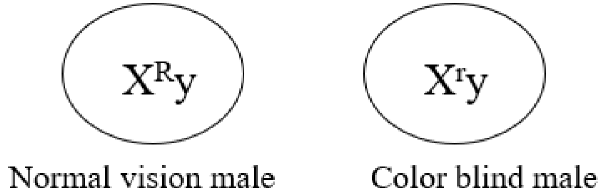


Female
Male
X^RX^r
×
X^rY
Sperm
X^r
Y
Eggs
X^R
X^r
X^RX^r
X^RY
X^rX^r
X^rY
R = red-eye allele
r = white-eye allele

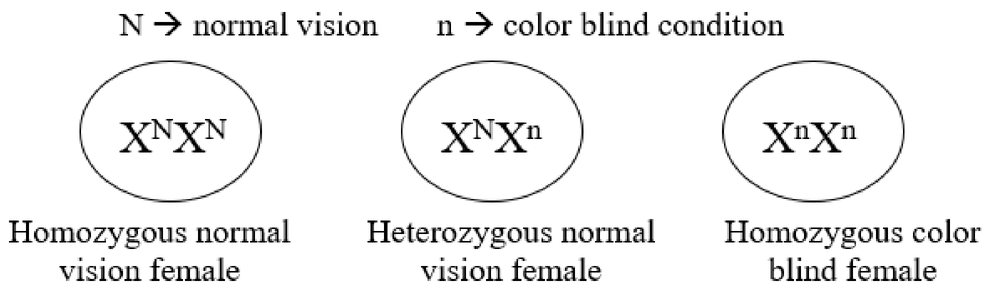
Human Sex-Linked Disorders affect mostly Males

- Most sex-linked human disorders are
  - due to **recessive alleles**
  - seen mostly in **males**

- A **male** receiving a single X-linked recessive allele from his mother will have the disorder.



- A **female** must receive the allele from both parents to be affected.

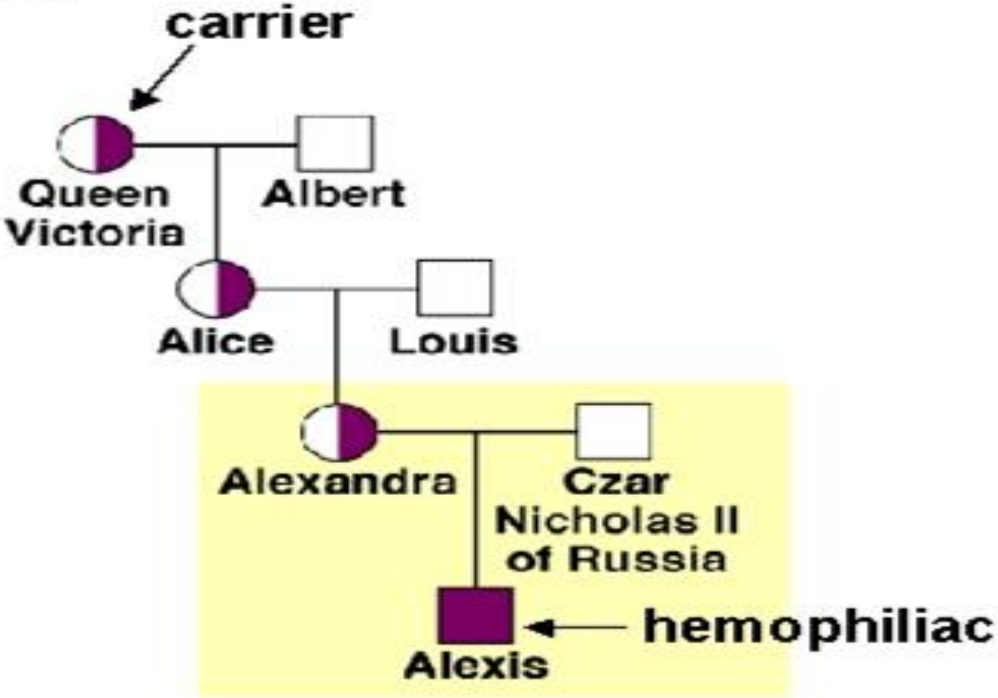


Human Sex-Linked Disorders affect mostly Males

- **Recessive** and **Sex-Linked** human disorders include:
  - **Hemophilia**, characterized by excessive bleeding because hemophiliacs lack one or more of the proteins required for blood clotting.
  - **Red-Green Colorblindness**, a malfunction of light-sensitive cells in the eyes.
  - **Duchenne Muscular Dystrophy**, a condition characterized by a progressive weakening of the muscles and loss of coordination.

Sex-Linked Disorders

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



QUICK CHECK

A normal woman, whose father had hemophilia, married a normal man. What is the chance of hemophilia in their children?

What is the genotype of the woman’s father?

What is the genotype of the woman?

What is the genotype of the man?

Genotypes	Phenotypes

A normal woman, whose father had hemophilia, married a normal man. What is the chance of hemophilia in their children?

What is the genotype of the woman's father? X^hY

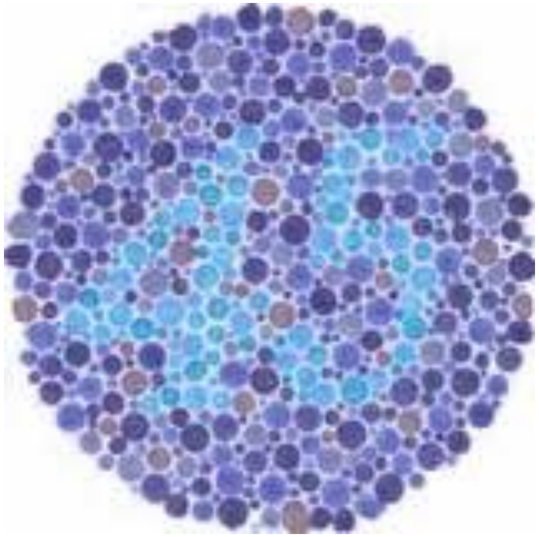
What is the genotype of the woman? X^HX^h

What is the genotype of the man? X^HY

	X^H	X^h
X^H	X^HX^H	X^HX^h
Y	X^HY	X^hY

Genotypes	Phenotypes
1/4 X^HX^H	2/4 Normal female
1/4 X^HX^h	1/4 Normal male
1/4 X^HY	1/4 Hemophiliac male
1/4 X^hY	

TRY IT



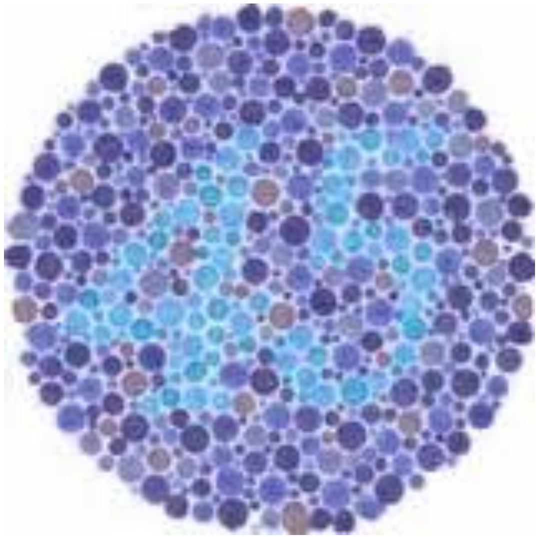
The gene for colorblindness is carried on the X chromosome and is recessive. A man, whose father was colorblind, has a colorblind daughter.

1. Is this man colorblind? How do you know?

2. Where did the man get his gene for colorblindness?

3. Must the fathers of all colorblind girls be colorblind? Explain.

TRY IT

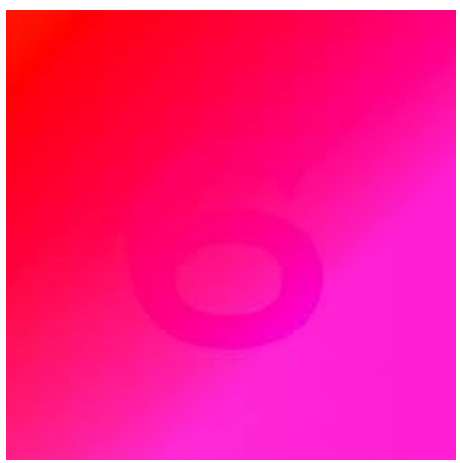


The gene for colorblindness is carried on the X chromosome and is recessive. A man, whose father was colorblind, has a colorblind daughter.

1. Is this man colorblind? How do you know?
   Yes. The colorblind daughter had to get one of her genes for colorblindness from her father.

2. Where did the man get his gene for colorblindness?
   A man gets his gene for colorblindness from his mother. He gets his Y chromosome from his father.

3. Must the fathers of all colorblind girls be colorblind? Explain.
   Yes. For a girl to be colorblind, she must inherit the colorblind gene from each parent.



Polygenic Inheritance: a Single Character may be Influenced by Many Genes

- Many characters result from **Polygenic Inheritance**
  - a single phenotypic characteristic results from the additive effects of two or more genes scattered on various homologous chromosomes.
  - in different loci.
- Many genes affect one individual trait, showing a gradation or gradient of small differences in expression. This is known as **Continuous Variation** in the phenotype.
  - **There is no clear-cut distinction in the genes – the number of genes involved is not known.**
  - Examples: Human **Skin Colo**r and **Height**

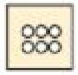
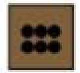
Continuous Variation in Human Skin Color as a Result of Polygenic Inheritance

Polygenic Inheritance: a Single Character may be Influenced by Many Genes

Human Skin Color:

- This is controlled by as many as 6 genes, each with its own alleles.
- The alleles control the production of **melanin**, which is a pigment that colors skin.
- In this example, the calculation is performed with **3 genes each with 2 alleles.**
- The cross is between two individuals heterozygous for all 3 genes.

P generation

 × 

aabbcc **(very light)**

AABBCC **(very dark)**

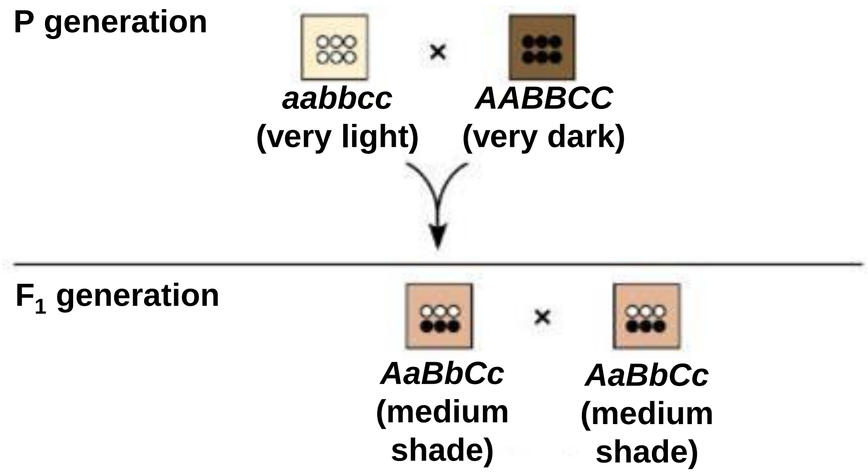
Allele Key:

A = adds melanin

a = no melanin added

B = adds melanin

b = no melanin added



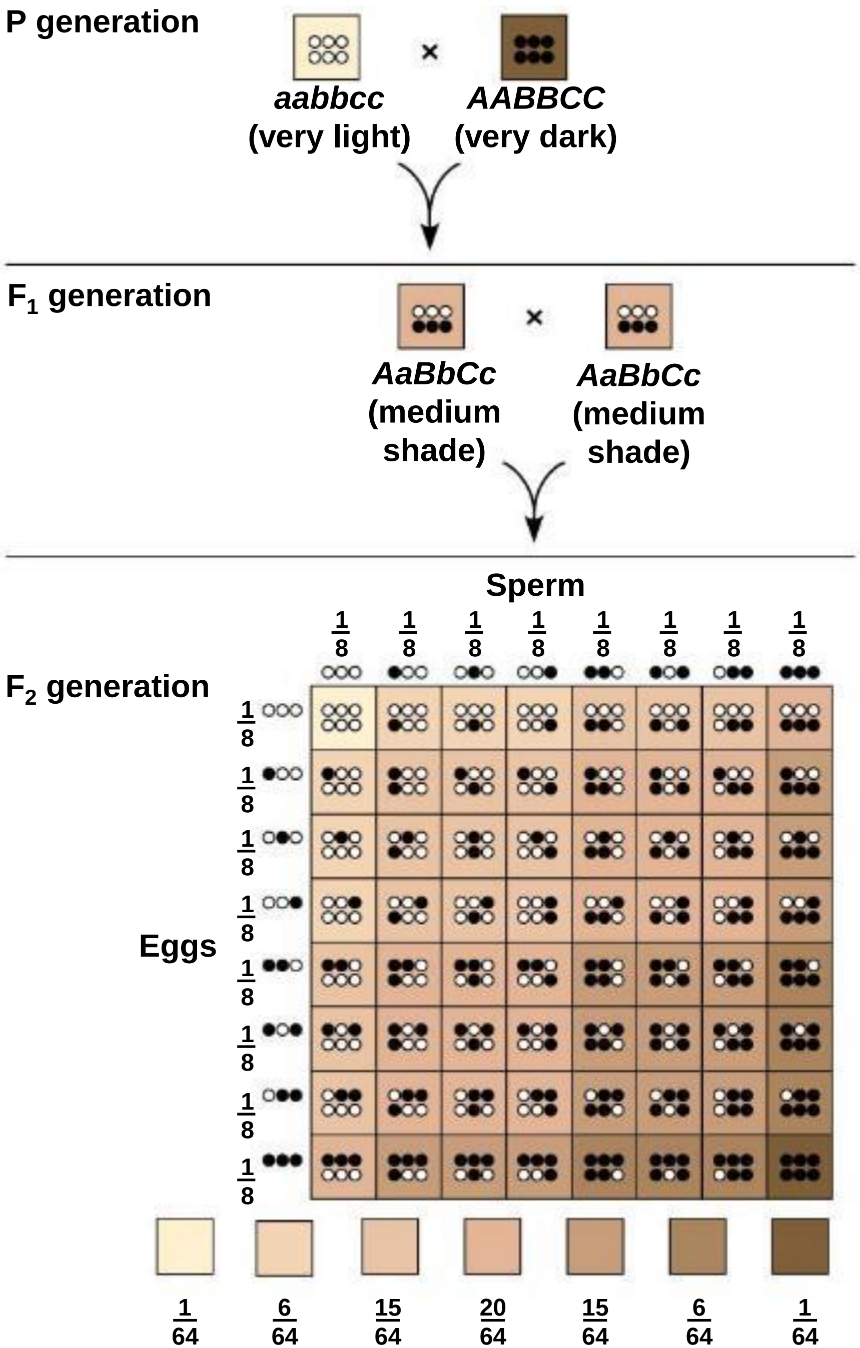
Allele Key:

A = adds melanin

a = no melanin added

B = adds melanin

b = no melanin added



Allele Key:

A = adds melanin

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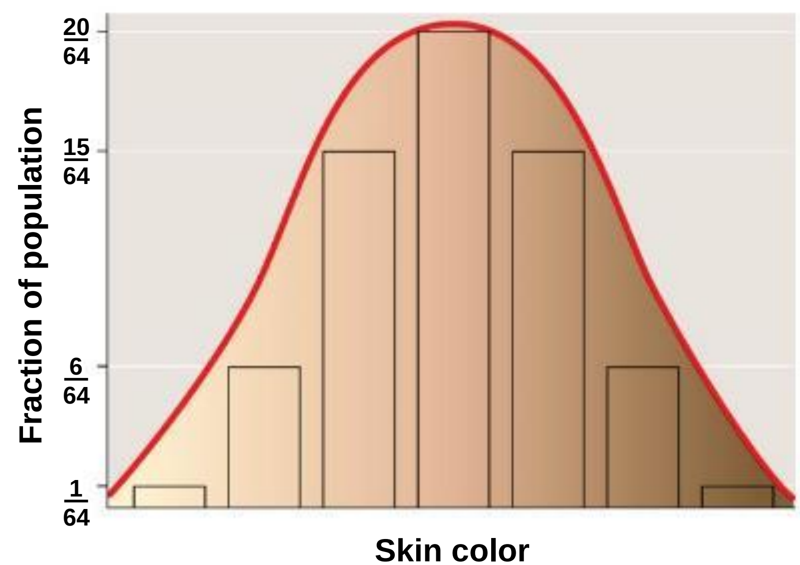
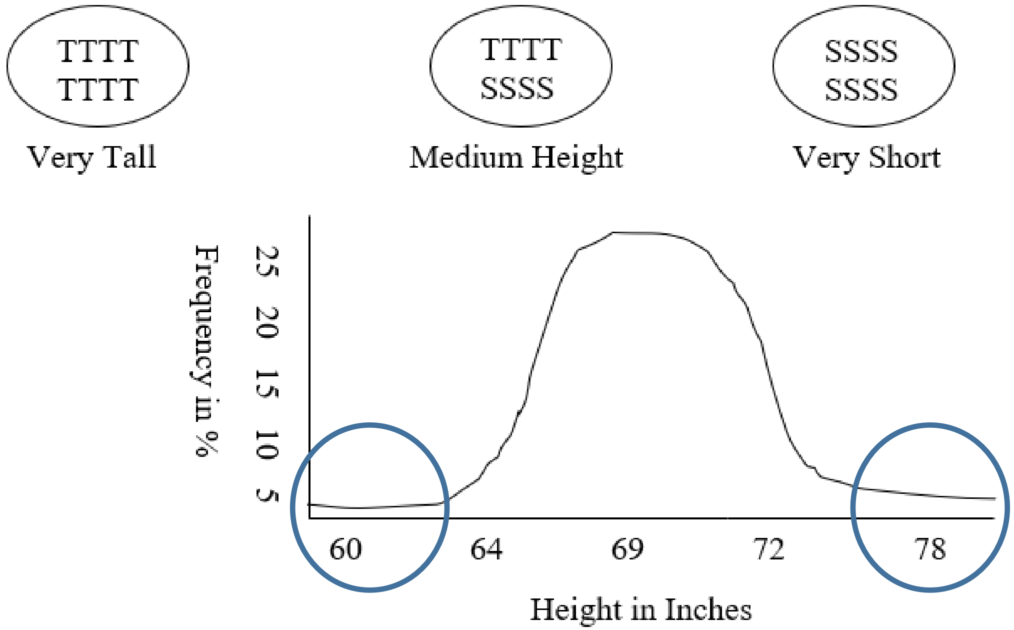


Polygenic Inheritance: a Single Character may be Influenced by Many Genes

Human Height

- Assume that 4 pairs of genes are involved (8 alleles).
- **Extremes** are represented by only a few individuals.
- Multiple Gene Inheritance has been found with up to 5 different genes involved.



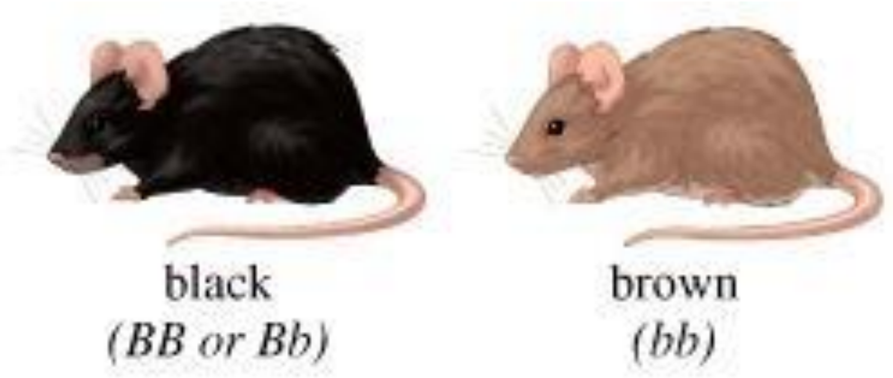
Epistasis (Modifier Genes)

- Occurs when **one or more genes that do not code for a trait** modify the way the trait is expressed.
- **Modifier Genes** do not code directly for a trait, but influence how the gene or genes that do code for the trait are expressed.
- So even though an organism may have a gene coding for a trait, the trait may not be expressed because of the epistatic interaction causing **suppression** of the trait for which the gene codes.

Epistasis (Modifier Genes)

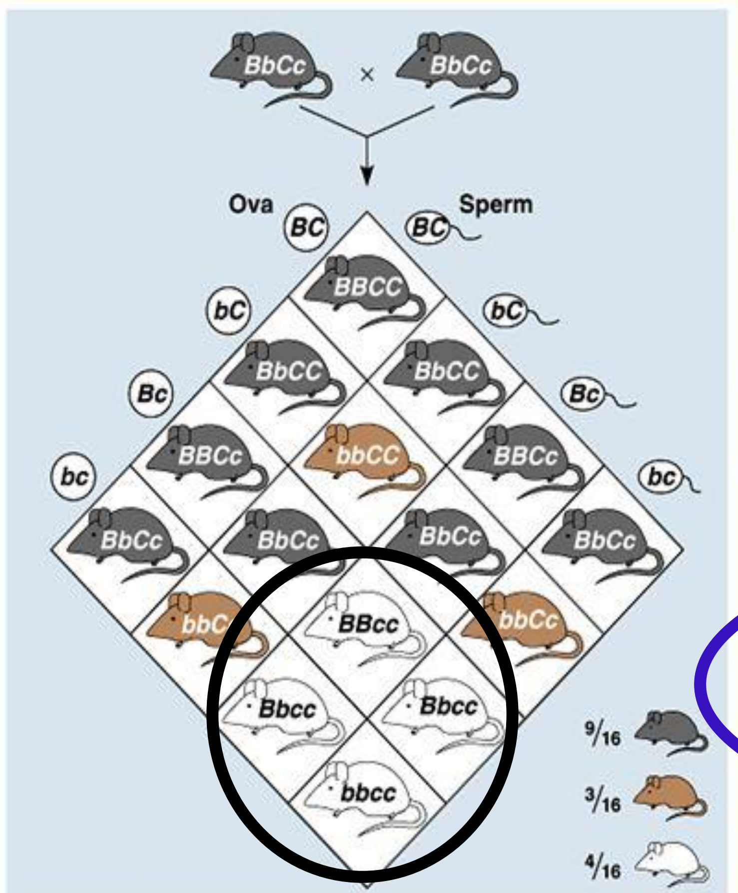
Example: Mice Coat Colors

- ✓ Mice have two coat colors: Black and Brown.
- ✓ Black (BB/Bb) is dominant to the Brown (bb).
- ✓ A mouse homozygous dominant or heterozygous will have black coat.
- ✓ A mouse homozygous recessive will have Brown coat.
- ✓ However, there is another gene that determines whether the pigment will be deposited or not.



EPISTASIS

- Gene at one locus alters the phenotypic expression of a gene at another locus



EX: Coat color in mice

B = Black b = brown

C = color deposited in coat

c = color NOT deposited

cc-mouse looks white even though it has color genes

Epistasis (Modifier Genes)

TRY IT

Male & Female Pattern Baldness

The recessive trait causes hormone repression of the dominant trait.

One parent is homozygous dominant (BB) bald.

One parent is homozygous normal hair (bb).

Show the genotype and phenotype of the P, F_1, and F_2 generations.

Epistasis (Modifier Genes)

TRY IT

Male & Female Pattern Baldness

The female sex hormone represses the expression of a dominant gene when in the HETEROZYGOUS state

In the heterozygous state, the recessive alleles cause repression by the female hormone, it's as if the recessive alleles become dominant.

B → bald condition   bb → normal hair condition

Parents

	B	**B**
b	Bb	Bb
b	Bb	Bb

F_1   100% Bb

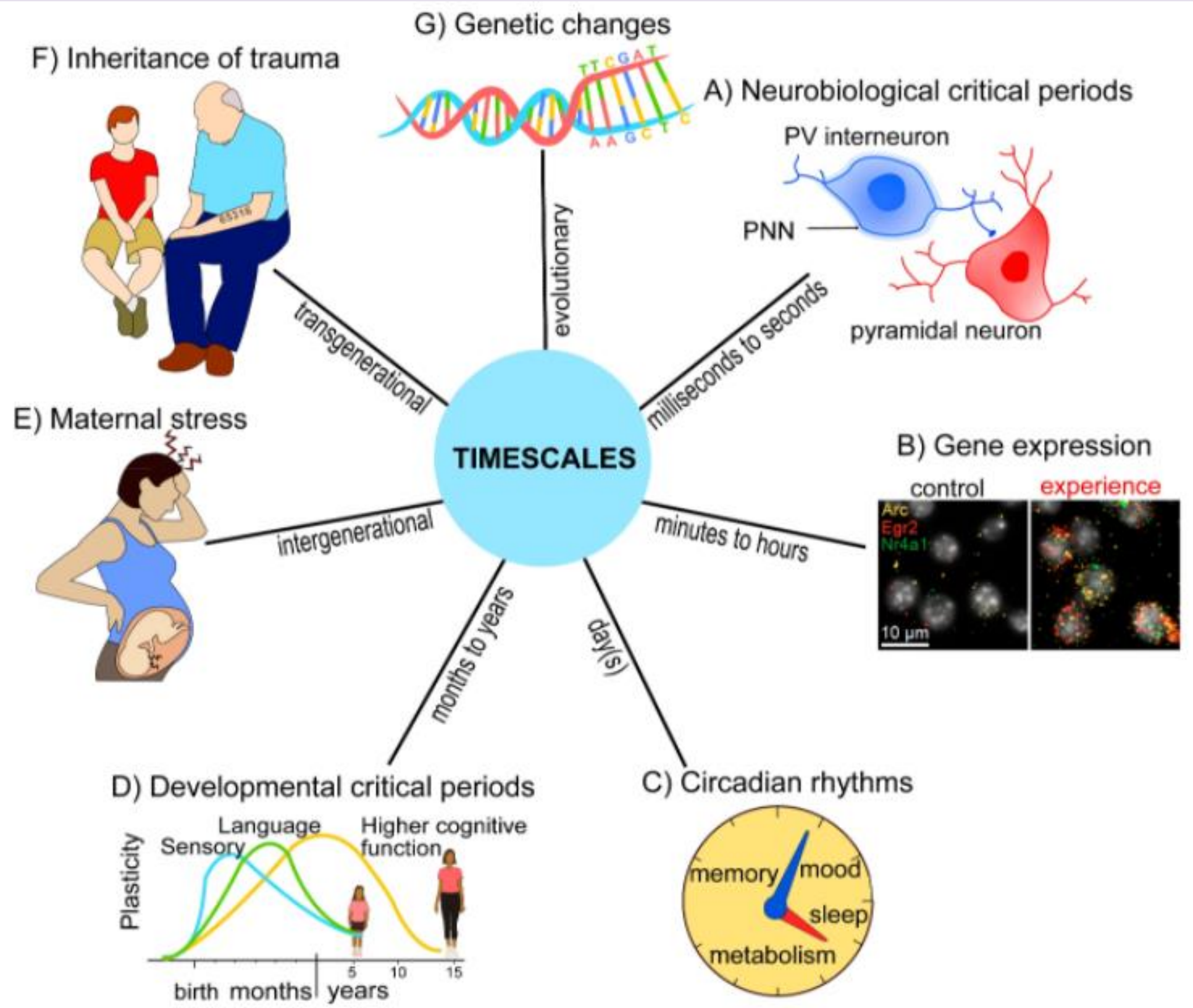
F_1 x F_1   **Bb x Bb**

F_1	**B**	**b**
B	BB	Bb
b	Bb	bb

F_2

75%	BB & Bb	bald males
25%	bb	normal hair males
25%	BB	Bald females (thinning)
75%	Bb & bb	normal hair females

Genes and the Environment



Gene Expression is always the result of the interaction of:

1. **Genetic Potential**

   with the

2. **Environment**

Genes and the Environment

Plants grown in light Plants grown in darkness

- A seedling may have the genetic capacity to be green, to flower, and to fruit, but it will never do these things if it is kept in the dark.
- A tree may never grow tall if the soil is poor and no water is available.

- In other words, the presence of the gene is not all that is required for the **expression of a trait**. The **gene** must be present along with the proper **environmental conditions**.
- The **Phenotype** of any organism is the result of interaction between **Genes** and the **Environment**.

Genes and Environment

- ✓ Environmental factors **CANNOT** change the genetic material.
- ✓ Changes in an organism due to environmental factors are **never passed** from parent to offspring.