
Genetics



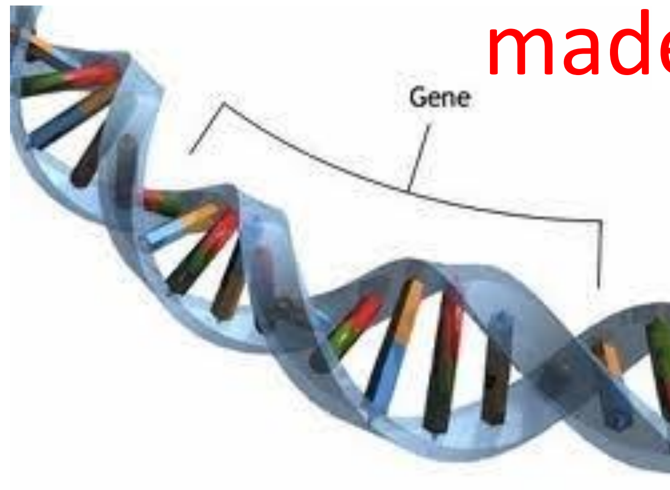
….the science that studies how genes are transmitted from one generation to the next.

Genes and Chromosomes

The chromosomes are contained in the _nucleus_ of the cell.

Gene: A segment of DNA that controls a hereditary trait.

Chromosomes are made of: **DNA**



Chromosome: A long chain of genes.

Trait:

The characteristics that an organism has, such as hair color, eye color, tall or short, skin color.

Two alleles must be present in order for a trait to show up in the offspring. One must come from Mom and the other from Dad. When fertilization occurs, the new offspring will have 2 alleles for every trait.

Gregor Mendel

Gregor Mendel was an Austrian monk who was born in 1822.

He is known as the Father of Genetics.

He discovered three laws of genetics that would forever change biology. He conducted a series of experiments in a quiet monastery garden. Mendel spent 14 years growing and experimenting with the pea plants grown in his garden.

Mendel gave us the three basic laws of inheritance which are still used today:

The Law of Dominance and Recessiveness

The Principle of Segregation

The Principle of Independent Assortment

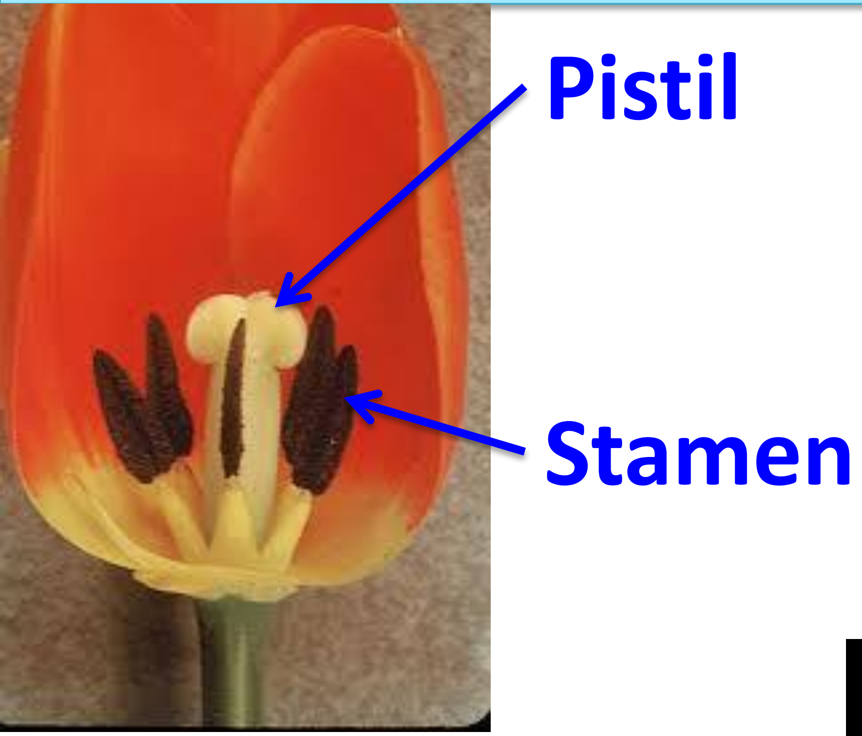
Mendel's great contribution was to demonstrate that inherited characteristics are carried by genes.

Mendel chose for his experiments the garden pea. It was a good choice because:

1. They were readily available.
2. They were easy to grow.
3. They grew rapidly.

The sexual structures of the flower are completely enclosed within the petals so that there would be no accidental cross-pollination between plants.

Before we learn about Mendel's experiments, let's review the basics of sexual reproduction in flowering plants.



Flowers contain both male and female reproductive structures.

The female part of the flower:
The pistil produces egg cells.

The male part of the flower:
The stamen produces pollen which contains sperm cells.

When the pollen is delivered to the pistil, the sperm travels to the egg cell, and the result is fertilization.

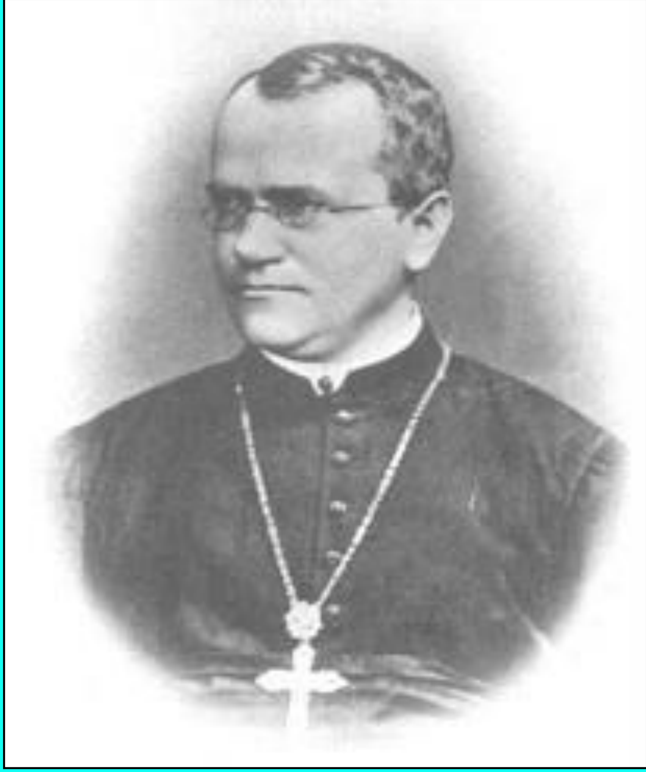
Fertilization produces:
a tiny embryo, which is enclosed inside a seed.

Mendel's Use of Pea Plants for Genetics Experiments

Pea flowers are normally _self-pollinating__. Since the male and female reproductive structures are relatively enclosed inside the flower, the sperm of the flower will fertilize the egg of the same flower.

The resulting embryos will have the same characteristics__ as the parent plant. Even though sexual reproduction has occurred, there is just one parent_.

Mendel knew that these pea plants were "true breeding". This means that if they are allowed to self-pollinate, they would produce: offspring identical to themselves.



For example: If allowed to self-pollinate, tall plants would always produce tall plants. Plants with yellow seeds would always produce offspring with yellow seeds.

These true breeding plants were the cornerstone of Mendel's experiments.

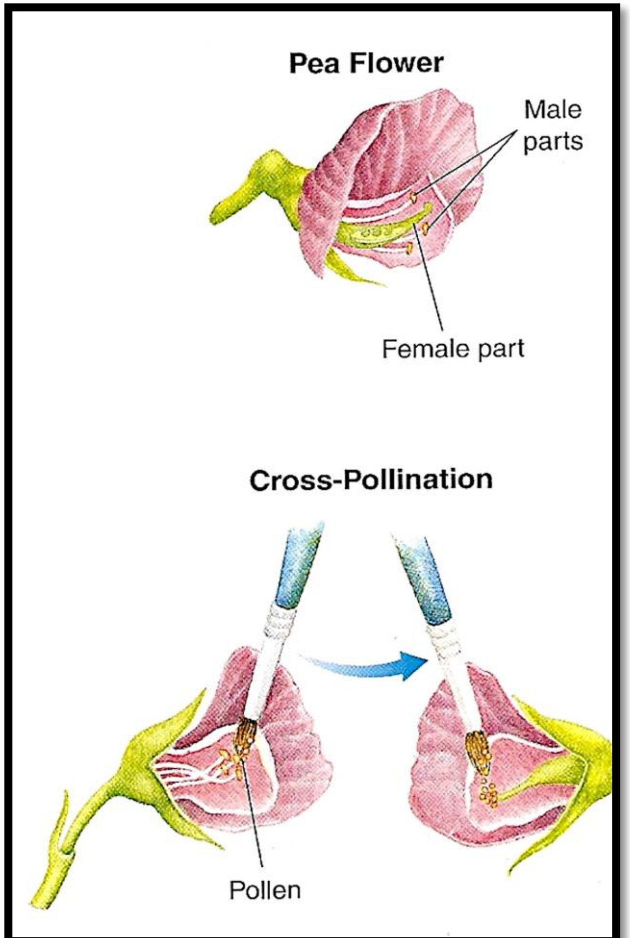
Mendel's Work

Mendel wanted to produce seeds by joining the egg and sperm from _two different plants_.
To do this, he had to first prevent the possibility of _self-pollination_.

Mendel cut away the stamens, the male reproductive parts of the flower, and then dusted the remaining female structure with pollen from a different plant.

This is known as _cross-pollination_ and produces offspring from two _different_ parents.

Now Mendel could easily crossbreed plants and experiment with different characteristics.

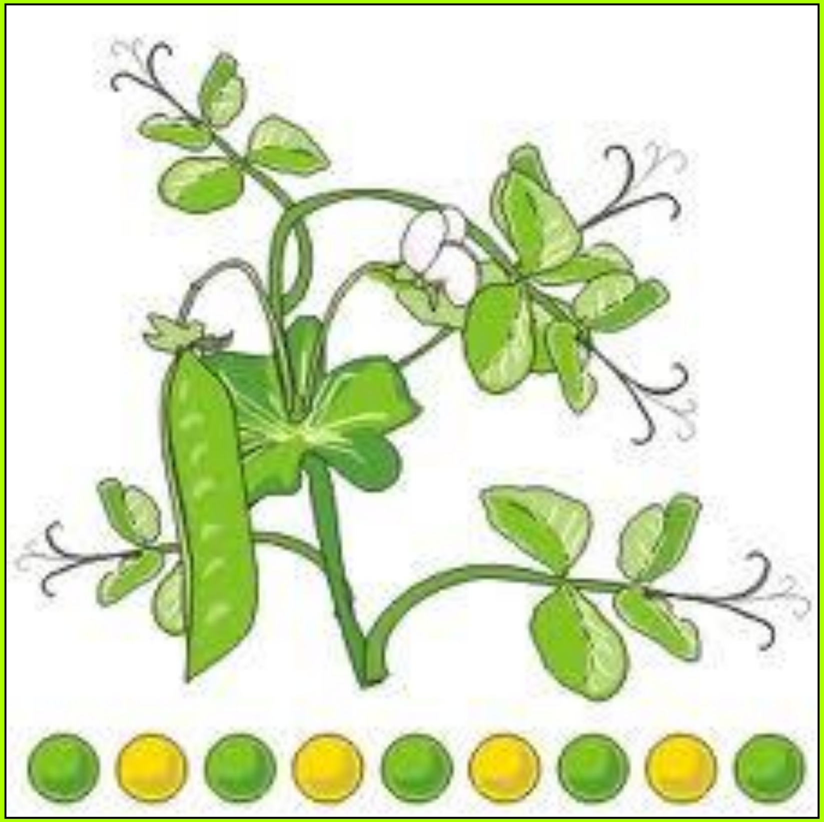


Which thumb do you put on top?

Before we proceed, you must be familiar with the following terms:

1. P generation: Parental generation
2. F_1 generation: First generation of offspring
3. F_2 generation: Second generation of offspring
4. Hybrids: The offspring of parents with different traits.

MENDEL'S EXPERIMENTS



Mendel crossed true-breeding tall plants with true-breeding dwarf plants.

Tall x dwarf → all tall offspring

1. The F_1 hybrids were all tall.
2. All of the offspring had the appearance of only one of the parents.
3. The trait of the other parent seemed to have disappeared. Mendel thought that the dwarf trait had been lost.

Mendel's Two Conclusions

Biological inheritance is determined by "factors" that are passed from one generation to the next.

Today, we know these factors to be _genes_.

Each of the traits that Mendel observed in the pea plants was controlled by _one gene_ that occurred in:

two contrasting forms.

For example: The gene for the height of pea plants occurs in a _tall_ form and in a _dwarf_ form. The different forms of a gene are called _alleles_.

Mendel realized that some alleles are dominant over other alleles.

Mendel's Seven F_1 Crosses on Pea Plants

	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position	Plant Height
P	Round X Wrinkled	Yellow X Green	Gray X White	Smooth X Constricted	Green X Yellow	Axial X Terminal	Tall X Short
F_1	Round	Yellow	Gray	Smooth	Green	Axial	Tall

Principle of Dominance and Recessiveness:

Some alleles are dominant and others are recessive. A dominant allele can cover up or mask a recessive allele.

Dominant allele: If the dominant allele is present in an offspring: the dominant trait will show up in the offspring.

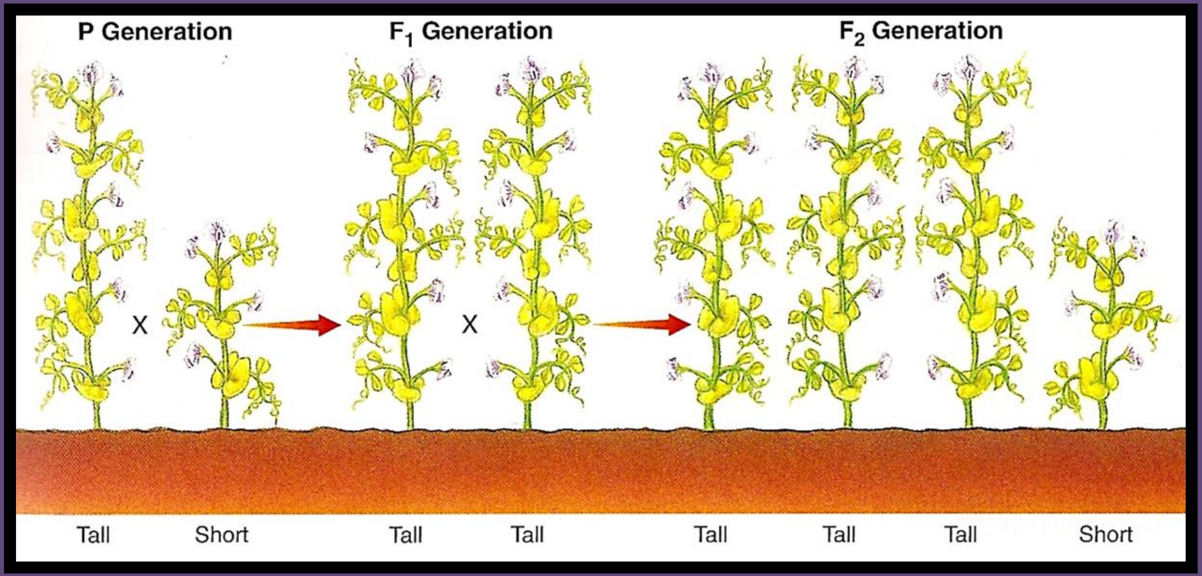
Recessive allele: This trait will show up in the offspring only if: the dominant allele is not present.

Mendel had another question:

Had the dwarf trait (recessive allele) disappeared, or was it still present in the F_1 offspring?

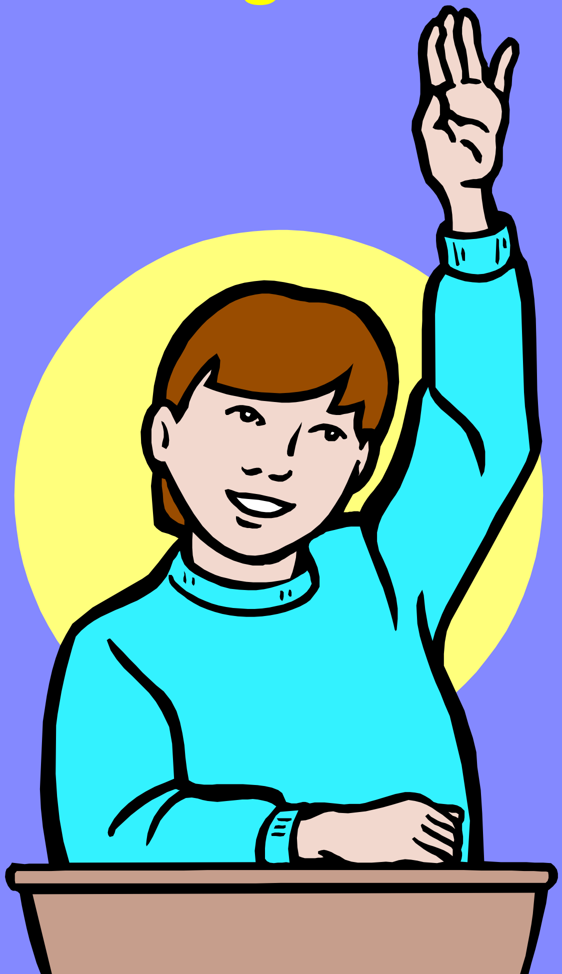
Mendel allowed the hybrid tall offspring from the first generation to self-pollinate.

F_1 Tall x F_1 Tall → offspring: ¾ tall and ¼ dwarf



1. He found that ¾ of the offspring were tall and ¼ of the offspring were dwarf.
2. Evidently the F_1 "tall" offspring must have been carrying the dwarf trait, but it had been hidden.
3. The dwarf trait had been passed down to the offspring and it reappeared in the F_2 generation.

Why did the recessive allele seem to disappear in the F_1 generation and then reappear in the F_2 generation?

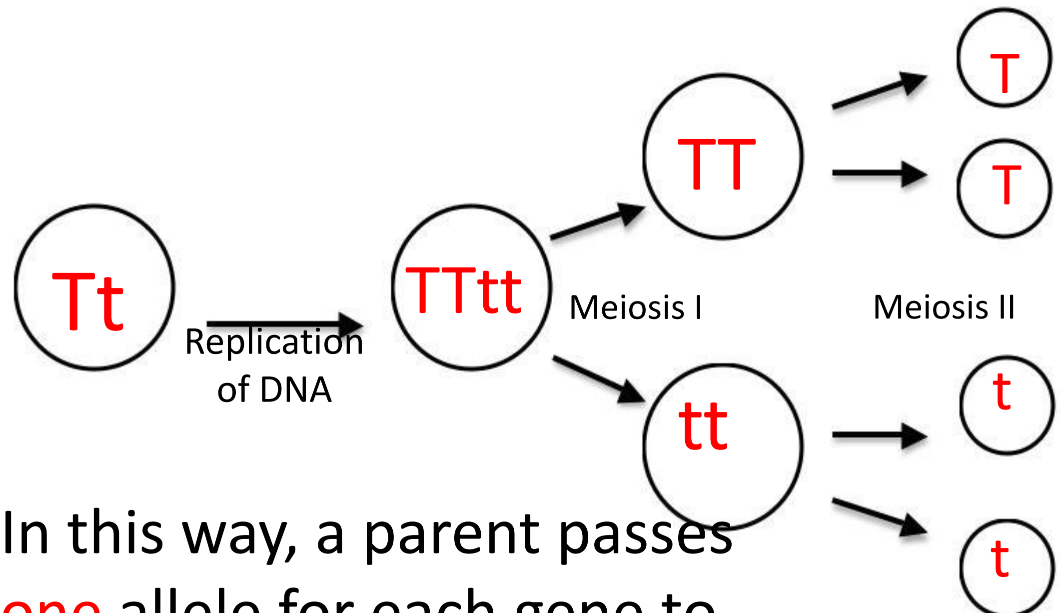


Mendel realized that organisms have two alleles for every trait. These two alleles are inherited, one from each parent. If the offspring receives a dominant allele from one parent, that dominant trait will appear in the offspring. Recessive traits show up in the offspring only if: the offspring receives recessive alleles from each parent.

If a parent has two alleles for a trait, how does the parent pass only one allele to the offspring?

Today, we know that the answer to this lies in the type of cell division known as meiosis, the formation of gametes.

Gametes are: sex cells or egg and sperm cells.



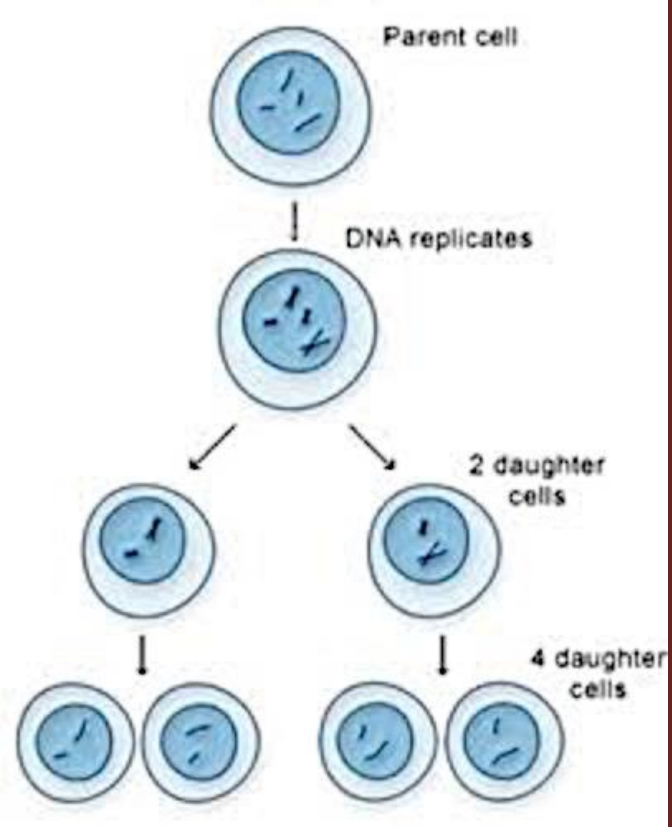
The capital letter, T, represents a dominant allele.

The lower case letter, t, represents a recessive allele.

During meiosis, the DNA is replicated and then separated into 4 gametes.

In this way, a parent passes one allele for each gene to their offspring.

Mendel's Principle of Segregation



Mendel's Principle of Segregation says that every individual carries 2 alleles for each trait. These two alleles separate or segregate during the formation of the egg and sperm cells.

HOMOZYGOUS OR HETEROZYGOUS?

An offspring will inherit two alleles for a trait, one allele from each parent. The combination of alleles received by the offspring may be either <u>homozygous or heterozygous.</u>

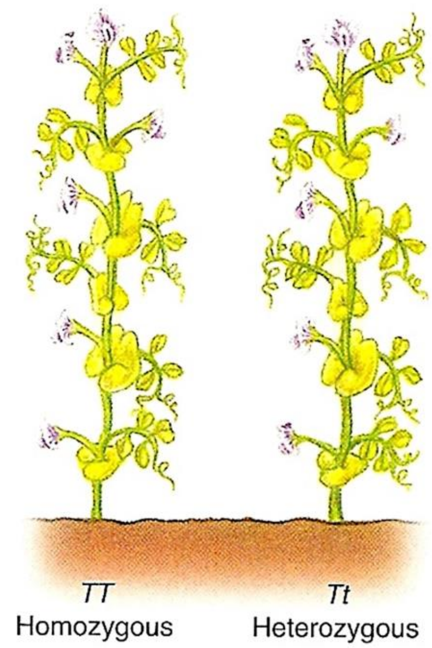
Homozygous means that…

…the two alleles are the same: TT or tt

Heterozygous means that…

…the two alleles are different: Tt

Genotypes and Phenotypes



A genotype is…

…the genetic makeup of an organism.

For example, in Mendel's pea plants, the tall allele was dominant over the dwarf allele:

Genotype	Phenotype
TT	Tall
Tt	Tall
tt	dwarf

A phenotype is…

…the physical characteristics of an organism – what the organism looks like.

If we know the genetic makeup of parents, what type of offspring might they produce?

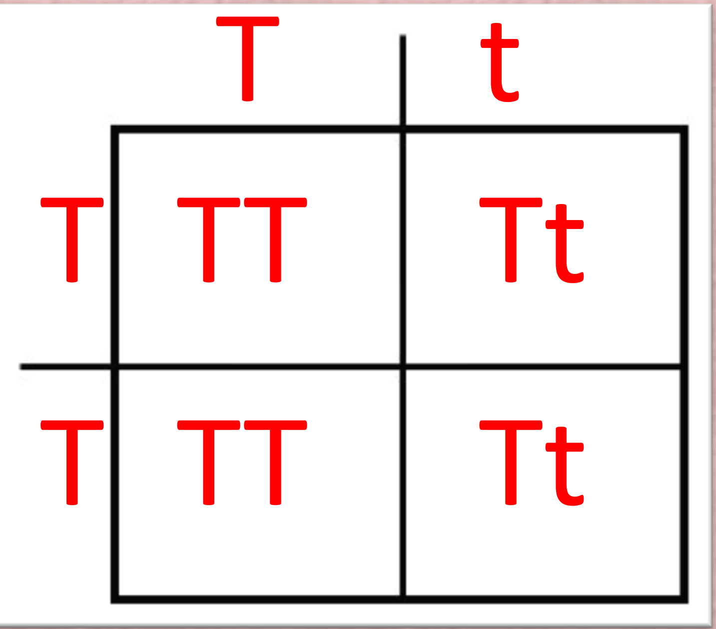
What is the probability of producing different types of offspring?

Probability:

Probability: The likelihood that a particular event will occur.

Using Probability and Punnett Squares to Work Genetics Problems

Punnett Square



1. A Punnett square is a diagram showing the __allele combinations__ that might result form a genetic cross between two parents.
2. The __alleles__ of the first parent will be placed across the __top__ of the square.
3. The __alleles__ of the second parent will be placed along the __left side__ of the square.
4. The possible gene combinations of the offspring will be placed inside the squares.
5. __Letters__ will represent the __alleles__.
6. A capital letter represents a __dominant__ allele.
7. A lower case letter represents a __recessive__ allele.

Mendel began his experiments using true-breeding parents. He soon discovered that the tall trait was dominant over the dwarf trait. Cross a true-breeding tall pea plant to a true-breeding dwarf pea plant.

What is the genotype of the first parent? TT

What is the genotype of the second parent? tt

Place the alleles of the first parent on the top of the square.
Place the alleles for the second parent on the left of the square.

Mendel's Peas

	T	T
t	Tt	Tt
t	Tt	Tt

Fill in the squares to show all the possible combinations of alleles that the offspring might inherit.

Use this table to show all possible genotypes and phenotypes of the offspring, and the probabilities of each.

Genotypes	Phenotypes
4/4 Tt	4/4 tall

In the above problem, none of the offspring will show the dwarf trait. As we learned earlier, Mendel wondered what had happened to the dwarf trait. He allowed the F_1 generation to self-pollinate.

Show this cross using the Punnett square below.

What is the genotype of each parent?

Tt x Tt

	T	t
T	TT	Tt
t	Tt	tt

Genotypes	Phenotypes
1/4 TT	¾ Tall
2/4 Tt	
1/4 tt	¼ dwarf

Having dimples is dominant over the absence of dimples. Cross a heterozygous dimpled man with a woman who does not have dimples. Show all work in the Punnett square and summarize your findings in the table.

What is the genotype of the man? Dd

What is the genotype of the woman? dd

	D	d
d	Dd	dd
d	Dd	dd

Genotypes	Phenotypes
2/4 Dd 2/4 dd	2/4 dimples 2/4 no dimples

Normal skin is dominant over albino skin. A woman who has normal skin, but whose father was albino, marries a heterozygous, normal skinned man. What type of offspring might they expect?

What is the genotype of the woman? Aa

What is the genotype of the man? Aa

	A	a
A	AA	Aa
a	Aa	aa

Genotypes	Phenotypes
1/4 AA 2/4 Aa 1/4 aa	¾ Normal ¼ albino

How many different genotypes are possible among the offspring? 3

How many different phenotypes are possible among the offspring? 2

What is the probability of getting homozygous offspring? 2/4

What is the probability of getting heterozygous offspring? 2/4

What is the probability of getting normal offspring? 3/4

What is the probability of getting albino offspring? 1/4

In dogs, the allele for short hair (B) is dominant over the allele for long hair (b). Two short haired dogs have a litter of puppies. Some of the puppies have short hair and some of the puppies have long hair.

What are the genotypes of the parents? Bb and Bb

	B	b
B	BB	Bb
b	Bb	bb

Genotypes	Phenotypes
1/4 BB	¾ short hair
2/4 Bb	¼ long hair
1/4 bb	

If the litter of puppies contained 12 pups, how many would you expect to have short hair? ¾ of the 12 should have short hair. ¾ of 12 = 9 pups

How many would you expect to have long hair? ¼ of 12 = 3 pups

The Principle of Independent Assortment

Mendel needed to answer one more question:

When alleles are being segregated during gamete formation, does the segregation of one pair alleles have any affect on the segregation of a different pair of alleles?

In other words, does the gene that determines if a pea plant is tall or dwarf have any affect on the gene for seed color?

Mendel designed a second set of experiments to follow two different genes as they passed from parent to offspring. This is known as a:

Two-factor cross or a dihybrid cross

One parent had peas that were round and yellow and the other parent had peas that were wrinkled and green. The round and yellow traits were dominant.

First, Mendel crossed true-breeding parents.

Round, yellow peas x wrinkled, green peas → All F_1 offspring had round, yellow peas.

RRYY x rryy

If round and yellow are dominant, what is the genotype of all of the F_1 offspring? RrYy

Next, Mendel allowed these hybrid F_1 offspring to self-pollinate.

When the first generation was allowed to self-pollinate (RrYy x RrYy), it resulted in the production of 556 seeds:

315 round, yellow (dominant, dominant)
105 round, green (dominant, recessive)
104 wrinkled, yellow (recessive, dominant)
32 wrinkled, green (recessive, recessive)

This meant that the alleles for seed shape had segregated independently of the alleles for seed color.
The alleles for one gene had _no effect_ on the alleles of another trait.
This is known as _“independent assortment”_.

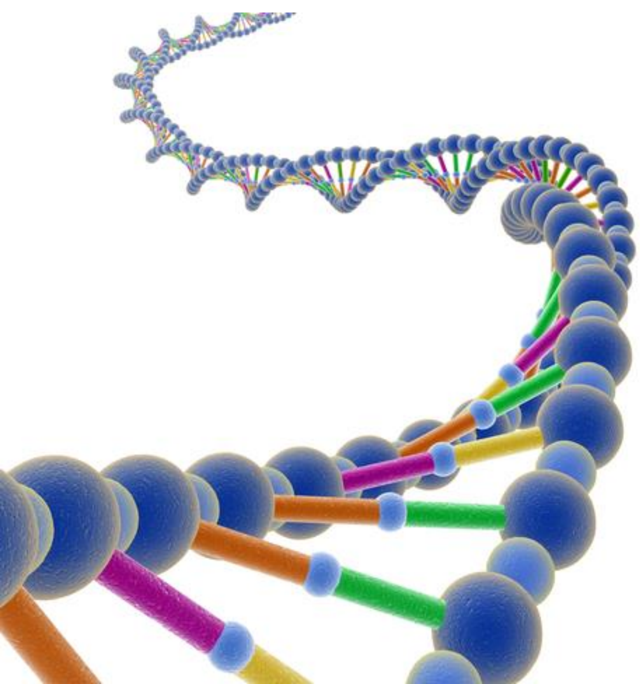
The Principle of Independent Assortment states:

When gametes are formed, the alleles of a gene for one trait segregate independently of the alleles of a gene for another trait.

Using a Punnett square for a two-factor or dihybrid cross

- ✓ When two traits are being considered, the Punnett square will need 16 squares.
- ✓ Each parent will pass one allele of each gene pair to the offspring.

Given the following parental genotypes, what alleles could each parent pass to their offspring?



If the parent was AaBb: AB, Ab, aB, ab

If the parent was Aabb: Ab, Ab, ab, ab

If the parent was aaBb: aB, ab, aB, ab

If the parent was AABB: AB, AB, AB, AB

Use the following Punnett square to illustrate Mendel's experiments.

True-breeding Round and Yellow x True-breeding wrinkled and green

What is the genotype of each parent? RRYY and rryy

What allele combinations can be passed to the offspring?

	RY	RY	RY	RY
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy
ry	RrYy	RrYy	RrYy	RrYy

Genotypes	Phenotypes
16/16 RrYy	16/16 Round, yellow

If the offspring from the above cross are allowed to self-pollinate:

Round and Yellow x Round and Yellow

What is the genotype of each parent? RrYy and RrYy

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

Genotypes	Phenotypes
1/16 RRYY 2/16 RRYy 1/16 RRyy 2/16 RrYY 4/16 RrYy 2/16 Rryy 1/16 rrYY 2/16 rrYy 1/16 rryy	Round,yellow 9/16 Round, green 3/16 Wrinkled, Yellow 3/16 Wrinkled, green 1/16

Practice Problem: Right handedness (R) is dominant over left handedness (r). The ability to roll your tongue (T) is dominant over the inability to roll your tongue (t).

What offspring might be expected from a cross involving the following parents: RRtt x RRTt

	Rt	Rt	Rt	Rt
RT	RRTt	RRTt	RRTt	RRTt
Rt	RRtt	RRtt	RRtt	RRtt
RT	RRTt	RRTt	RRTt	RRTt
Rt	RRtt	RRtt	RRtt	RRtt

Genotypes	Phenotypes
8/16 RRTt	8/16 Right handed, tongue roller
8/16 RRtt	8/16 Right handed, nonroller

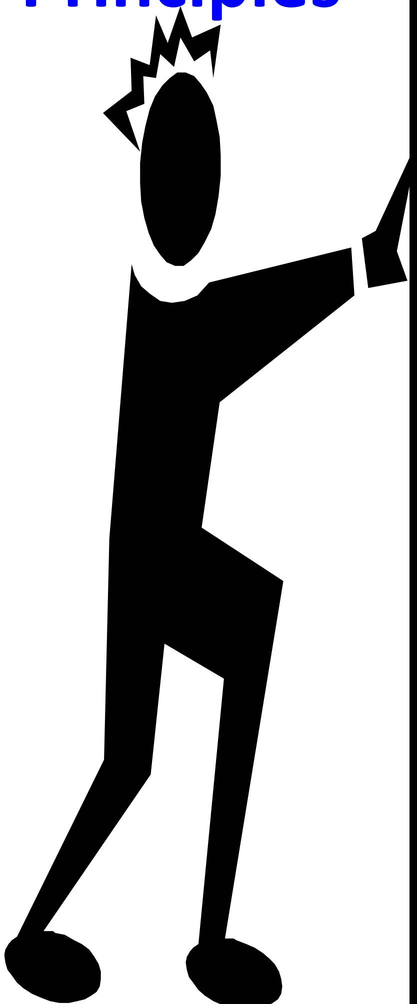
A woman, who is right handed and a tongue roller, has a father who is left handed and cannot roll his tongue. She marries a heterozygous right handed, tongue rolling man. What possible offspring might they expect?

What is the genotype of the woman? RrTt
What is the genotype of the man? RrTt

	RT	Rt	rT	rt
RT	RRTT	RRTt	RrTT	RrTt
Rt	RRTt	RRtt	RrTt	Rrtt
rT	RrTT	RrTt	rrTT	rrTt
rt	RrTt	Rrtt	rrTt	rrtt

Genotypes	Phenotypes
1/16 RRTT	9/16 Right handed tongue rollers
2/16 RRTt	
1/16 RRtt	3/16 right handed nonrollers
2/16 RrTT	
4/16 RrTt	3/16 left handed tongue rollers
2/16 Rrtt	
1/16 rrTT	
2/16 rrTt	1/16 left handed nonrollers
1/16 rrtt	

A Summary of Mendel's Principles



Mendel's principles form the basis of modern genetics. Mendel's principles include the following:

1. The inheritance of traits is determined by individual units known as genes.

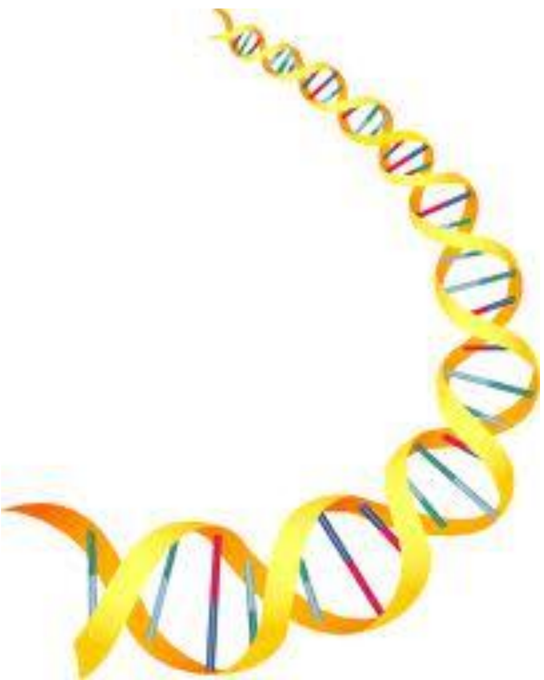
2. Genes are passed from parent to offspring.

3. Each gene has two or more forms called alleles.

4. Some alleles are dominant, while other alleles are recessive.

5. Each parent has two alleles for a particular trait that they inherited from their parents. They will pass one allele to their offspring when the alleles are segregated into gametes.

6. The alleles for one trait segregate independently of the alleles for another trait.



There are some exceptions to these 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. Now we will begin to examine some of these exceptions to Mendel's rules.

Genes and the Environment

Plants grown in light   Plants grown in darkness

Gene expression is always the result of the interaction of:

genetic potential with the environment.

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.

Incomplete Dominance or Nondominance

 +  = 

All traits are not so clear-cut as dominant and recessive traits.

For example: In some flowers, such as snapdragons and four o'clocks, a homozygous red flower crossed with a homozygous white flower yields a _heterozygous pink_ flower.

Some genes appear to: blend together.

This is known as:

incomplete dominance or nondominance.

No allele is dominant or recessive - they blend together in the offspring.

Since there is no recessive allele, use only _capital_ letters. For example: A red flower would be _RR_, and white flower would be _WW_, and the pink hybrid would be _RW_.

 +  = 

What type of offspring might be produced by two pink flowering plants?

What are the genotypes of the parents? RW and RW

	R	W
R	RR	RW
W	RW	WW

Genotypes	Phenotypes
1/4 RR	1/4 Red
2/4 RW	2/4 Pink
1/4 WW	1/4 White

In a certain plant, flower color shows nondominance, but the stem length shows dominance. The allele for long stem is dominant over the allele for short stem. Cross a heterozygous long stemmed, red plant with a short stemmed pink plant.

What is the genotype of the first parent? LlRR

What is the genotype of the second parent? llRW

	LR	LR	lR	lR
lR	LlRR	LlRR	llRR	llRR
lW	LlRW	LlRW	llRW	llRW
lR	LlRR	LlRR	llRR	llRR
lW	LlRW	LlRW	llRW	llRW

Genotypes	Phenotypes
4/16 LlRR	4/16 Long, red
4/16 LlRW	4/16 Long, pink
4/16 llRR	4/16 short, red
4/16 llRW	4/16 short, pink

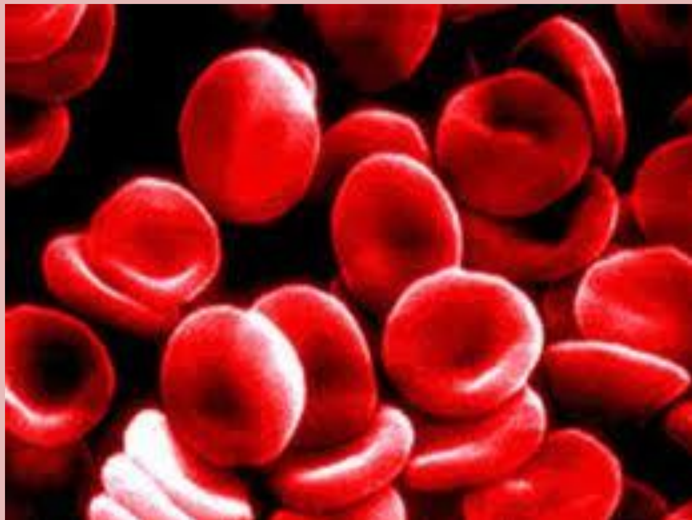
Codominance

In humans, four blood types are possible:
A, B, AB, and O

There are <u>three</u> alleles that determine blood type. These three alleles are written as follows: I^A, I^B, and i.

Alleles I^A and I^B are <u>codominant</u>, and the allele "i" is <u>recessive</u>.

Codominance:
Both dominant alleles are apparent in the phenotype of the heterozygous offspring.



The possible genotypes for blood types are as follows:

Genotypes	Phenotypes
$I^A I^A$	Type A blood
$I^A i$	Type A blood
$I^B I^B$	Type B blood
$I^B i$	Type B blood
$I^A I^B$	Type AB blood (Since these alleles are codominant, both are expressed in the offspring)
i i	Type O blood

What types of offspring might be expected if one parent has type AB blood and the other parent is heterozygous for type A blood?

What is the genotype of the first parent? $I^A I^B$

What is the genotype of the second parent? $I^A i$

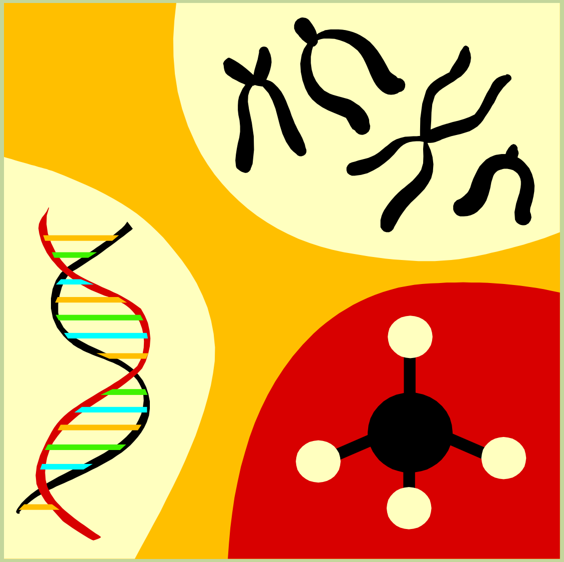
	I^A	I^B
I^A	$I^A I^A$	$I^A I^B$
i	$I^A i$	$I^B i$

Genotypes	Phenotypes
¼ $I^A I^A$	Type A blood 2/4
¼ $I^A I^B$	Type AB blood 1/4
¼ $I^A i$	Type B blood 1/4
¼ $I^B i$	

A man and a woman have four children. Each child has a different blood type. What are the genotypes of the parents and the four children?

The parents would have to be:

$I^A i$ and $I^B i$.



What are the genotypes of the four children?

The type O child is ii.
The type AB child is $I^A I^B$.
The type A child is $I^A i$.
The type B child is $I^B i$.

Another component of our blood type is the Rh factor.
Some people have Rh positive blood and others have Rh negative blood.
The Rh factor is determined by one gene with two alleles.
The allele for Rh positive is dominant over the allele for Rh negative.
Let's use "R" to represent the positive allele and "r" to represent the negative allele.

Work this problem: A woman whose blood type is AB negative marries a man with blood type O positive. The man's mother had blood that was A negative.

What is the genotype of the woman? $I^A I^B rr$

What is the genotype of the man? ii Rr

What is the genotype of the man's mother? $I^A i\ rr$

	I^A r	I^A r	I^B r	I^B r
iR	I^Ai Rr ✓	I^Ai Rr ✓	I^Bi Rr ✓	I^Bi Rr ✓
ir	✓ I^Ai rr	✓ I^Ai rr	✓ I^Bi rr	✓ I^Bi rr
iR	I^Ai Rr ✓	I^Ai Rr ✓	I^Bi Rr ✓	I^Bi Rr ✓
ir	I^Ai rr ✓	I^Ai rr ✓	I^Bi rr ✓	I^Bi rr ✓

Genotypes	Phenotypes
4/16 I^Ai Rr	4/16 Type A Rh positive
4/16 I^Ai rr	4/16 Type A Rh negative
4/16 I^Bi Rr	4/16 Type B Rh positive
4/16 I^Bi rr	4/16 Type B Rh negative

Multiple Alleles

Many genes have two or more alleles and are said to have multiple alleles .

This means that there are two or more alleles for the trait.

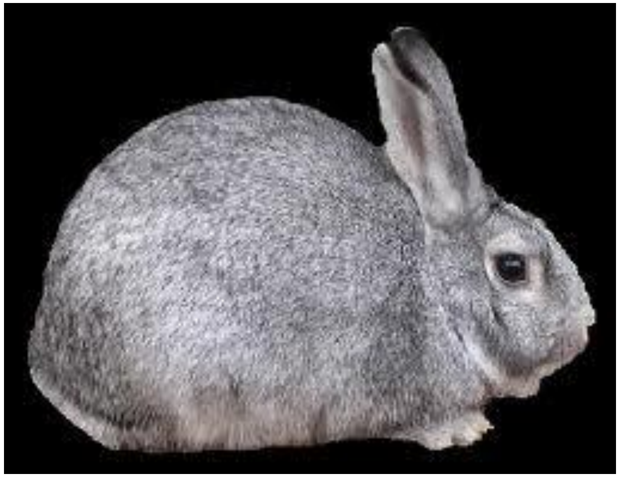
The best example for multiple alleles involves coat color in rabbits.

Coat color in rabbits is determined by a single gene that has at least 4 different alleles.

These four alleles demonstrate a dominance hierarchy in which some alleles are dominant over others.

The four alleles for coat color in rabbits in order of dominance are as follows:

C – Full color (often called wild type or agouti)



c^{ch} - light gray or chinchilla

c^{h} - albino with black extremities or

These alleles are listed in order of their dominance

What would be the possible genotypes of each of these rabbits?

c - albino

Full color: CC, C c^{ch}, Cc^{h} , Cc

Chinchilla: c^{ch} c^{ch}, c^{ch} c^{h}, c^{ch}c

Himalayan: c^{h} c^{h}, c^{h}c

Albino: cc

 +  = 

What types of offspring could be produced by a full color rabbit that had a genotype of C c^{ch} that was bred with a Himalayan rabbit that was c^h c?

	C	c^{ch}
c^h	C c^h	c^{ch} c^h
c	Cc	c^{ch} c

Genotypes	Phenotypes
¼ C c^h	2/4 Full color
¼ c^{ch} c^h	2/4 chinchilla
¼ Cc	
¼ c^{ch} c	

POLYGENIC INHERITANCE

In polygenic inheritance, the determination of a given characteristic is the result of:
the interaction of many genes.

Some traits, such as _size, height, shape, weight, color, metabolic rate, and behavior_ are not determined by one pair of alleles. These traits are the cumulative result of the combined effects of _many genes_. This is known as _polygenic inheritance_.

A trait affected by a number of genes - or polygenes - does not show a clear difference between groups of individuals. Instead, it shows a:

graduation of small differences

Many normal human traits are thought to be polygenic.

Examples:

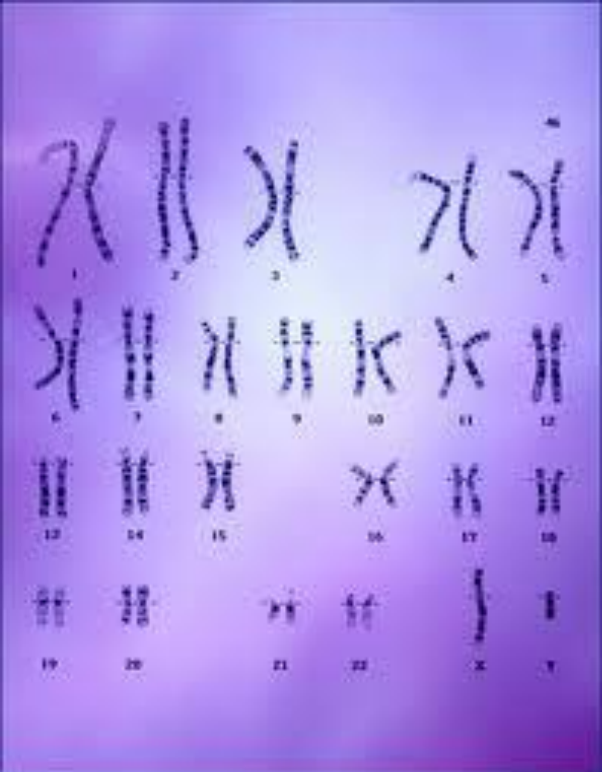
hair color

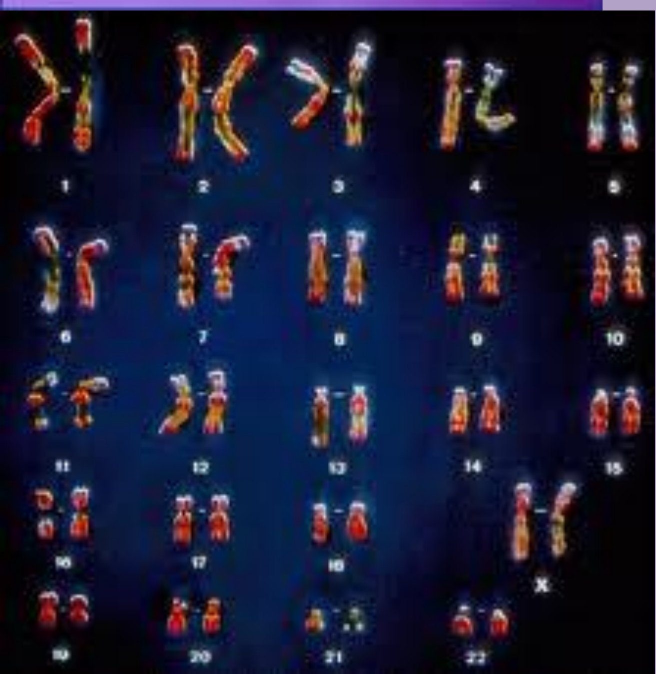
eye color

weight

height

skin color





Sex Determination

1. Human cells contain 23 pairs of chromosomes.

   There are 22 pairs of autosomes, and one pair of sex chromosomes.
2. In males and females, all of the pairs of chromosomes are the same except one pair. The pairs that are the same are called autosomes. Autosomes are all of the chromosomes within a cell except for the sex chromosomes.

3. One pair differs between males and females. This pair is called the sex chromosomes. The sex chromosomes differ in structure.

3. Females have 2 copies of a large X chromosome. Males have one X and one small Y chromosome.

Sex-Linked Genes

There are _many_ genes found on the X chromosome.
The Y chromosome appears to contain only a _few_ genes.

Since the X and Y chromosomes determine the sex of an individual, all genes found on these chromosomes are said to be _sex-linked_.

More than 100 sex-linked genetic disorders have now been associated with the X chromosome.

Sex-linked traits include _color blindness, hemophilia, and muscular dystrophy_.
These are caused by _recessive_ alleles.

Since males have only one copy of the X chromosome, they will have the disorder if they inherit just _one copy_ of the allele. Females must inherit _two copies_ of the allele, one on each of their X chromosomes, in order for the trait to show up. Therefore, sex linked genetic disorders are much more common in males than females.

Working Sex-linked problems

The genotypes for colorblindness would be written as follows:

$X^C X^C$ = normal vision female

$X^C X^c$ = normal vision female, but a carrier of the colorblind allele

$X^c X^c$ = Colorblind female

$X^C Y$ = normal vision male

$X^c Y$ = Colorblind male

The genotypes for hemophilia would be written as follows:

$X^H X^H$ = normal blood clotting female

$X^H X^h$ = normal clotting female, but a carrier of hemophilia

$X^h X^h$ = hemophiliac female

$X^H Y$ = normal blood clotting male

$X^h Y$ = Hemophiliac male

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

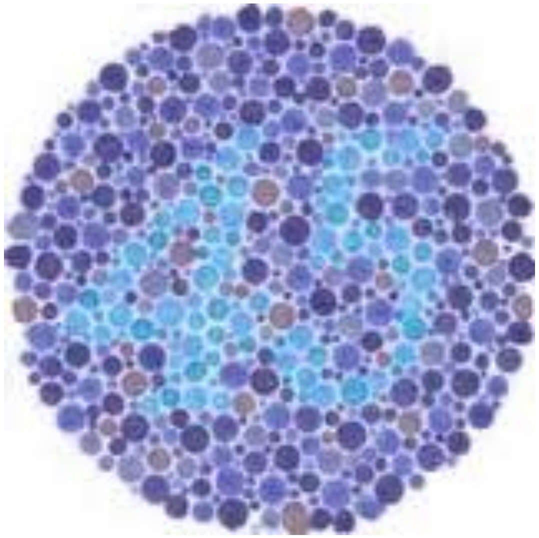
What is the genotype of the woman's father? X^hY

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	

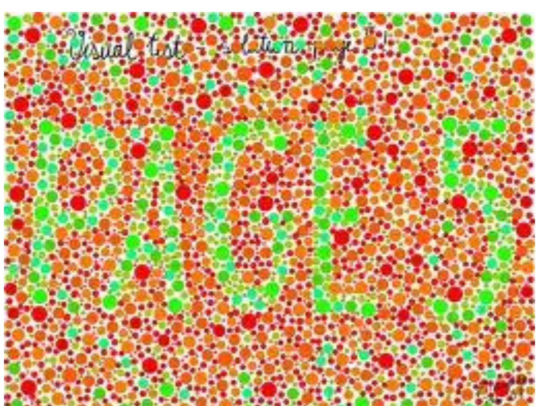


The gene for colorblindness is carried on the X chromosome and is recessive. A man, whose father was colorblind, has a colorblind daughter.

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.



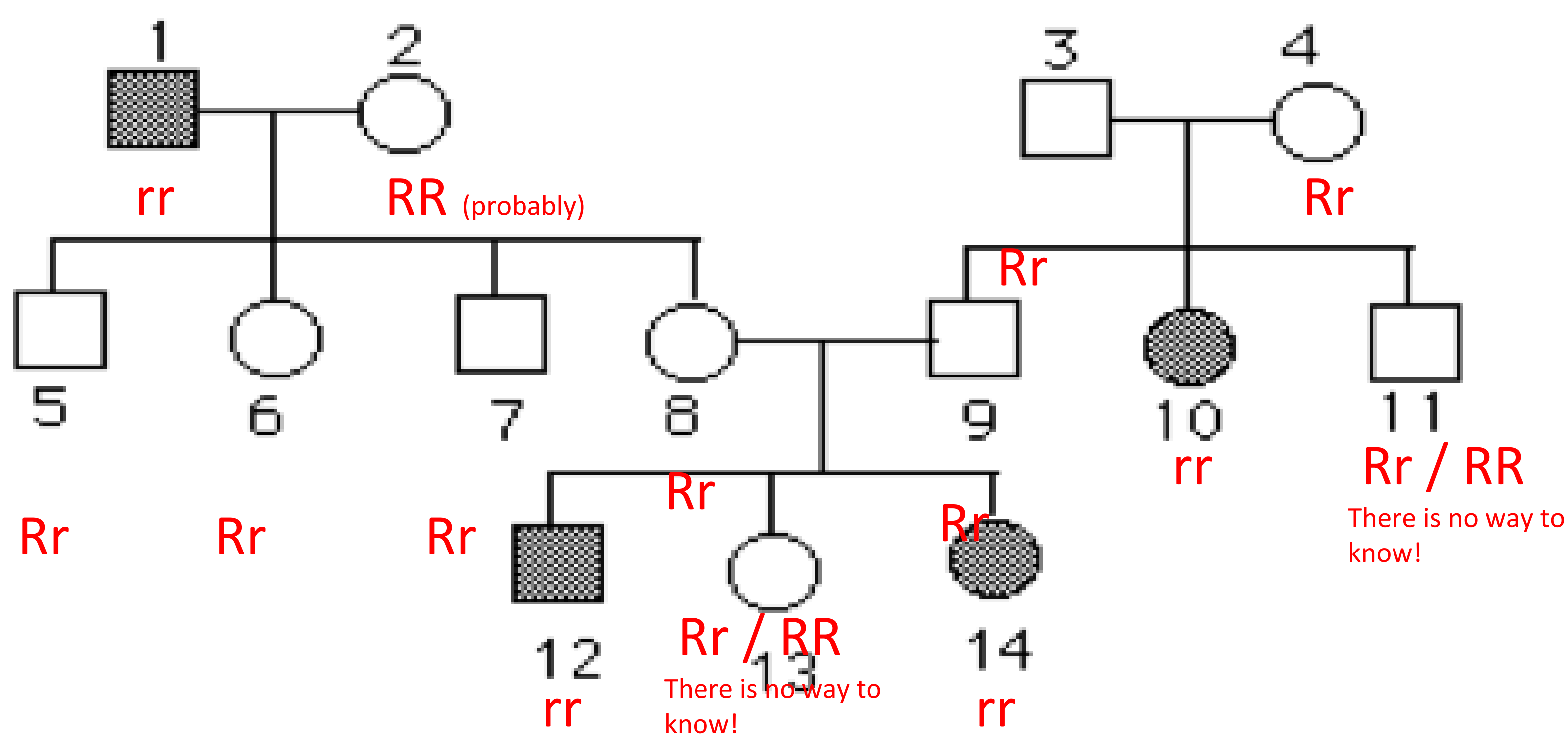
Genealogy Tables (Pedigree Charts)

A. A pedigree chart shows relationships within a family.

B. Squares represent males and circles represent females.

C. A shaded circle or square indicates that a person has the trait.

D. The following table shows three generations of guinea pigs. In guinea pigs, rough coat (R) is dominant over smooth coat (r). Shaded individual have smooth coat. What is the genotype of each individual on the table below?



The following pedigree table is for colorblindness. This is a sex-linked trait. Shaded individual have colorblindness. Determine the genotype of each of the following family members.