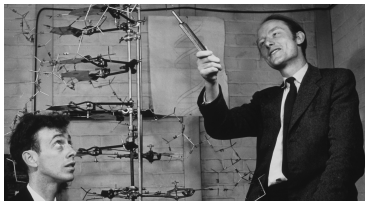
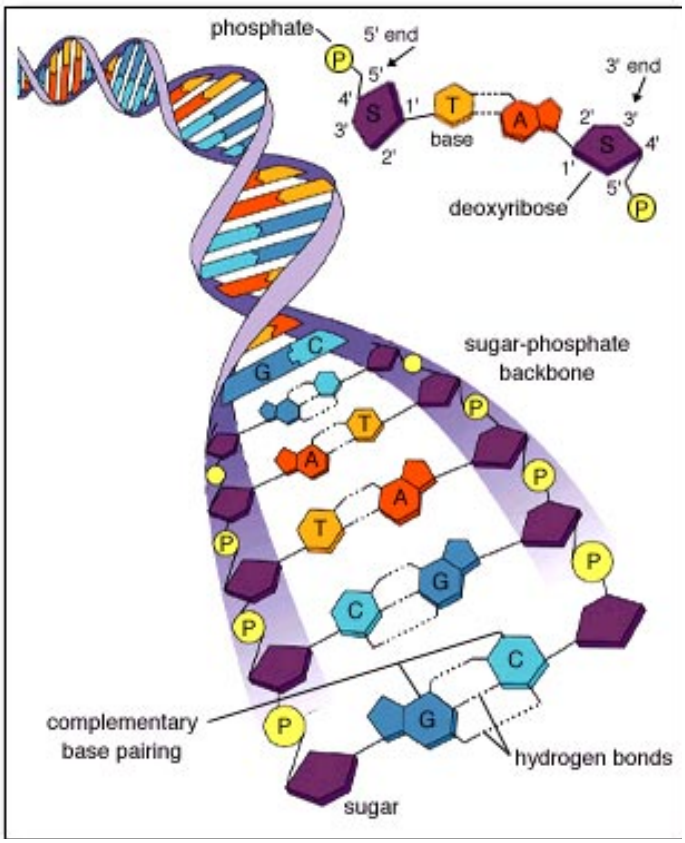
Unit Two: DNA and Heredity

Lesson 1: What is DNA?



The DNA Molecule

Deoxyribonucleic Acid is the molecule that encodes the genetic instructions used in the development and functioning of all known living organisms.

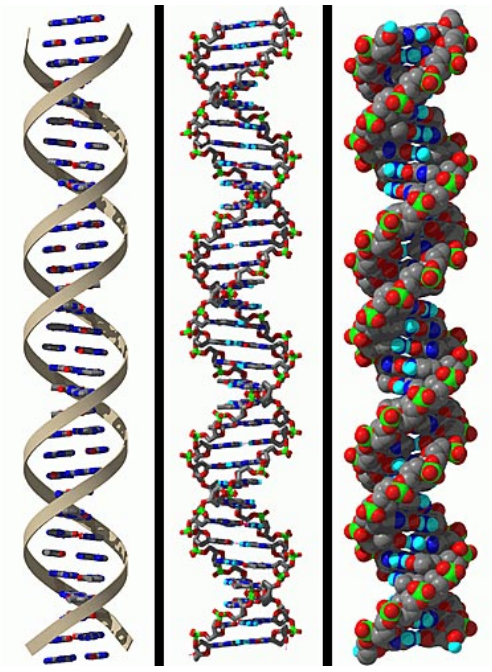


The structure of DNA was first described by Nobel Prize winners James Watson and Francis Crick in 1953.

The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T).

The DNA bases pair up with each other, A with T and C with G, to form units called base pairs.

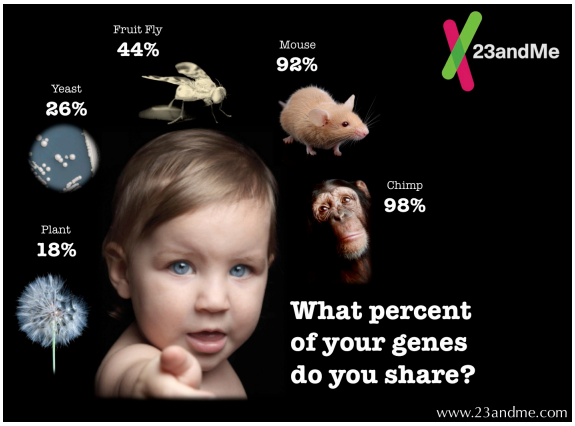
Each base is also attached to a sugar molecule and a phosphate molecule.



Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix.

The structure of the double helix is like a twisted ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.

Written out the base pairs in DNA make a sequence, e.g. A T A T C T C T T G A T G C G.

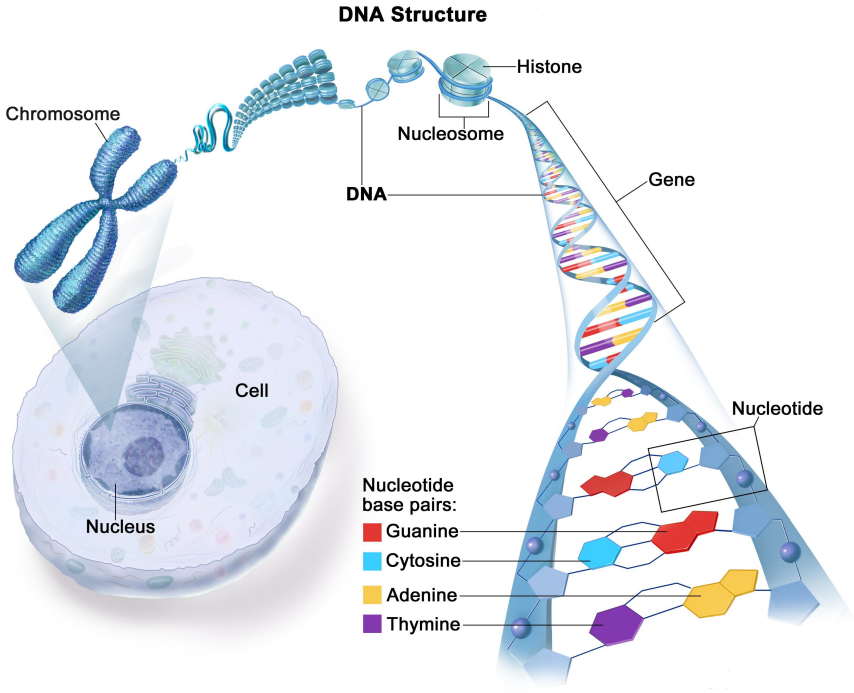


More than 99.9% of those bases are the same in all people.

The order, or sequence, of the letters determines the information available for building and maintaining an organism, similar to the way in which letters of the alphabet appear in a certain order to form words and sentences.

Chromosomes:

In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromatin. Chromatin is condensed further to form structures called chromosomes.



Humans have a total of 23 pairs of chromosomes.

Chromosome count in different organisms

Organism	Total number of chromosomes
Human	46
Dog	78
Goat	60
Yellowfever mosquito	6
Rice	24
Snail	24
Artichoke	34
King crab	208
Coton	50
Mouse	40
Pinapple	50
Tasmanian devil	14
Chicken	78
Honey bee	32
Grey wolf	78

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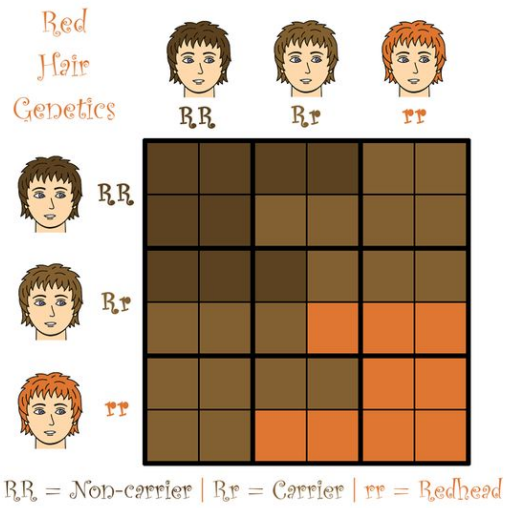
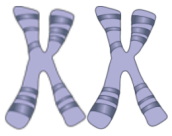
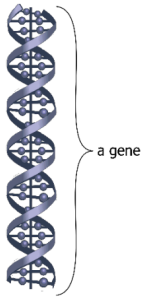
Genes:

Genes are formed from segments of DNA that range in size from 27,000 base pairs to 2,000,000 base pairs. Every human has the same set of genes - about 20,000 in all. The differences between people come from slight variations in these genes.



For example, a person with red hair doesn't have the "red hair gene" while a person with brown hair has the "brown hair gene." Instead, all people have genes for hair color, and different versions of these genes, called **alleles**, dictate whether someone will be a redhead or a brunette.

Complete the sentences using your knowledge and the keywords below.

chromosomes		Chromosomes are found inside the _____ of a cell. There are _____ pairs of chromosomes in every human body cell. One of each pair of chromosomes comes from each_____. Chromosomes are made up of long lengths of _____.
genes		A gene is a short section of a _____. Each gene _____ for a different _____. Genes work in _____. There are different versions of each gene, one is often _____ over the others.
DNA		DNA is short for _____ _____. It is a long chain _____ that is made up of a combination of _____ DNA bases. DNA has a special structure called a _____ _____.

Keywords

4	DNA	pairs	double	nucleus	characteristic	chromosome
23	codes	helix	molecule	parent	dominant	deoxyribonucleic acid

Draw lines to match up the beginning and the end of the sentences relating to chromosomes, genes and DNA.

DNA is short for ...	... called a double helix.
Chromosomes contain many genes that ...	... deoxyribonucleic acid.
Genetic material is found...	... 4 DNA bases.
There are 23 pairs ...	... controlled by genes.
DNA is a molecule made up of a combination of ...	... of a chromosome.
We inherit our genes ...	... code for our characteristics.
Each gene is a short section ...	... long coiled chains of DNA.
Chromosomes are made up of ...	... of chromosomes in the nucleus of a body cell.
DNA has a special structure ...	... in the nucleus of each cell.
Our characteristics are ...	... from our parents.

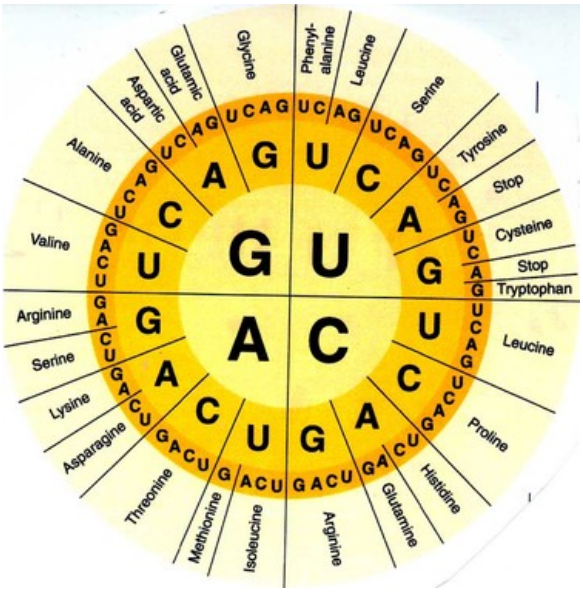
Lesson 2: The DNA Molecule
Amino Acids, Proteins and Codons?

A = ⌟	H = ⌜⌝	O = ⊠	V = ⊡
B = ⌞⌟	I = ⌜	P = ⊠	W = ⊡
C = ⌞	J = ⊠	Q = ⊠	X = ⊡
D = ⌝	K = ⊠	R = ⊠	Y = ⊡
E = □	L = ⊠	S = ⊡	Z = ⊡
F = ⌜	M = ⊠	T = ⊡	
G = ⌝	N = ⊠	U = ⊡	

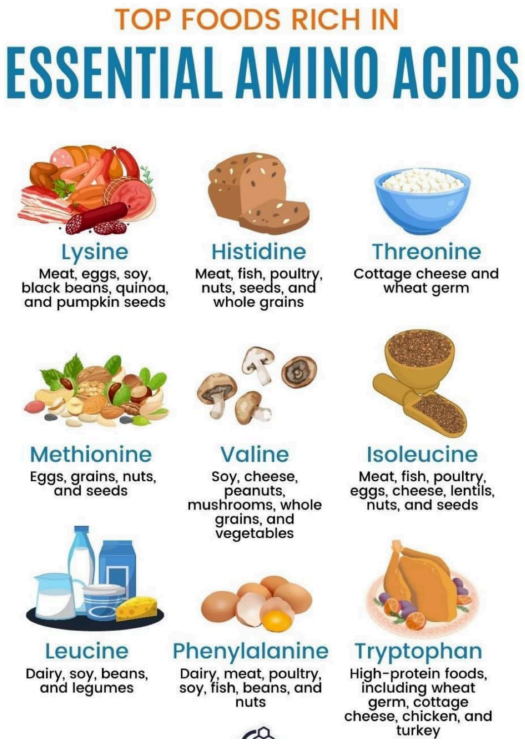
Proteins are the building blocks of all living things and responsible for nearly all aspects of normal biological function.

The proteins found in humans are made from varying combinations of 20 amino acids, 9 of which are called essential because they cannot be made in our bodies and must be derived from our diet.

The order in which proteins are assembled from their amino acids is determined by the order of the bases found in the RNA that is created for the purpose of protein synthesis.



RNA is Ribonucleic Acid. It differs from DNA in that it is only made of a single strand and the Thymine (T) in DNA is replaced by Uracil (U) in RNA.



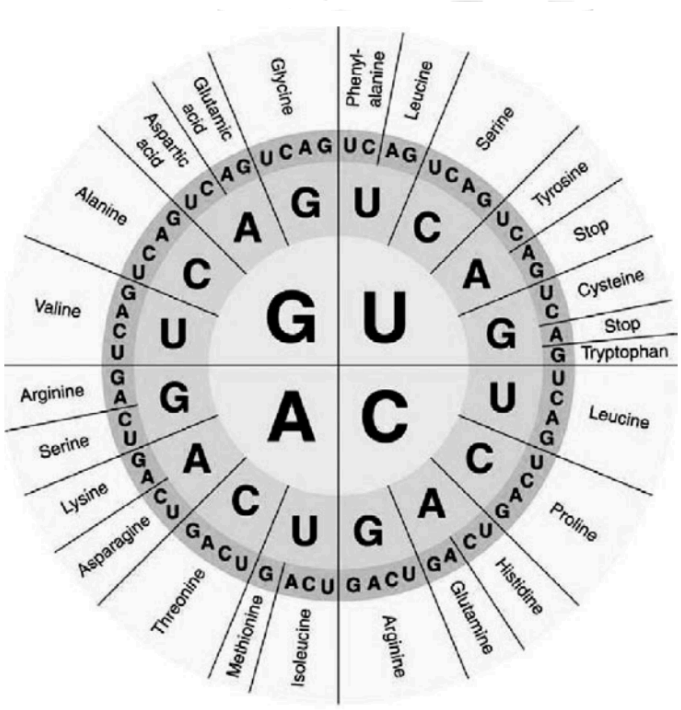
Amino acids are coded for according to the following chart:
Which amino acids would be coded for by:

CGAUCACUCAAACAGUGA

Worksheet – Determination of Protein Amino Acids from M-RNA's Codon chart.

Part 1 "Amino Acid / codon Wheel"

Instructions: The "**Wheel**" at the right shows you how to determine which amino acid goes with which m-RNA codon sequence. To decode a codon, start at the middle of the circle and move outward.



1. Identify the amino acids what will be produced from the following m-RNAs codon:
   a. AAC _____ b. UCU _____
   c. GAU _____ d. CCC _____

2. What would the codon sequence (s) be for:
   Leucine? _____
   Valine? _____

3. What are the m-RNA's stop codons: _____

4. What amino acid sequence would be made from the mRNA sequence CGCUAUAGC? _____

Part 2 "Amino Acid / codon Chart"

Instructions: The "Chart" at the right shows you how to determine which amino acid goes with which m-RNA codon sequence. To decode a codon, start with the **First Base**, then the **Second Base**, and finally the **Third Base**.

First Base	Second Base: U	Second Base: C	Second Base: A	Second Base: G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

1. Identify the amino acids (you can get the full name from the wheel) what will be produced from the following m RNAs codon:
   a. GUA _____ b. UUU _____
   c. CAC _____ d. UAA _____

2. Suppose the DNA sequence GCTATATCG was changed to GCGATATCG. How would the products of transcription and translation be affected?

	mRNA sequence		Amino acid sequence
GCTATATCG	→	_____	→ _____
GCGATATCG	→	_____	→ _____

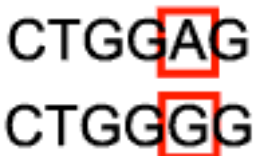
Lesson 3: Mutations

A mutation is a permanent alteration in the DNA sequence that makes up a gene.

Mutations range in size; they can affect anywhere from a single DNA base pair to an entire chromosome that includes multiple genes.

Types of Mutations

There are many different ways that DNA can be changed, resulting in different types of mutation. Here is a quick summary of a few of these:



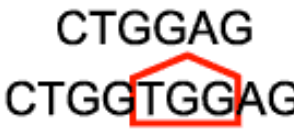
Substitution

A substitution is a mutation that exchanges one base for another (i.e., a change in a single "chemical letter" such as switching an A to a G).

Sickle cell anemia is caused by a substitution in the beta-hemoglobin gene, which alters a single amino acid in the protein produced.

Insertion

Insertions are mutations in which extra base pairs are inserted into a new place in the DNA.

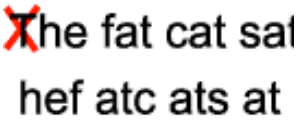


Deletion

Deletions are mutations in which a section of DNA is lost, or deleted.

Frameshift

Since protein-coding DNA is divided into codons three bases long, insertions and deletions can alter a gene so that its message is no longer correctly read. These changes are called frameshifts.



For example, consider the sentence, "The fat cat sat." Each word represents a codon. If we delete the first letter and decode the sentence in the same way, it doesn't make sense.

There are several types of mutation:

DELETION (a base is lost)

INSERTION (an extra base is inserted)

Deletion and insertion may cause what's called a **FRAMESHIFT**, meaning the reading "frame" changes, changing the amino acid sequence.

SUBSTITUTION (one base is substituted for another)

If a substitution ***changes*** the amino acid, it's called a **MISSENSE** mutation.
If a substitution ***does not change*** the amino acid, it's called a **SILENT** mutation.
If a substitution ***changes the amino acid to a "stop,"*** it's called a **NONSENSE** mutation.

Complete the boxes below. Classify each as either Deletion, Insertion, or Substitution **AND** as either frameshift, missense, silent or nonsense (hint: deletion or insertion will always be frameshift).

Original DNA Sequence: **T A C A C C T T G G C G A C G A C T**

mRNA Sequence: A U G U G G A A C C G C U G C U G A

Amino Acid Sequence: METHIONINE -TRYPTOPHAN - ASPARAGINE - ARGININE- CYSTEINE - (STOP)

Mutated DNA Sequence #1: **T A C A T C T T G G C G A C G A C T**

What's the mRNA sequence? (Circle the change)

What will be the amino acid sequence?

Will there likely be effects? What kind of mutation is this?

Mutated DNA Sequence #2: **T A C G A C C T T G G C G A C G A C T**

What's the mRNA sequence? (Circle the change)

What will be the amino acid sequence?

Will there likely be effects? What kind of mutation is this?

Mutated DNA Sequence #3: **T A C A C C T T A G C G A C G A C T**

What's the mRNA sequence? (Circle the change)

What will be the amino acid sequence?

Will there likely be effects? What kind of mutation is this?

Mutated DNA Sequence #4: **T A C A C C T T G G C G A C T A C T**

What's the mRNA sequence? (Circle the change)

What will be the amino acid sequence?

Will there likely be effects? What kind of mutation is this?

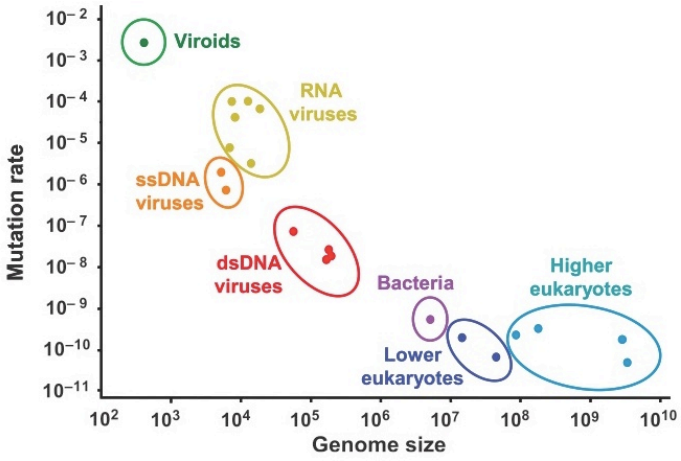
Mutated DNA Sequence #5: **T A C A C C T T G G G A C G A C T**

What will be the corresponding mRNA sequence?

What will be the amino acid sequence?

Will there likely be effects? What kind of mutation is this?

Lesson 4: Causes of Mutations

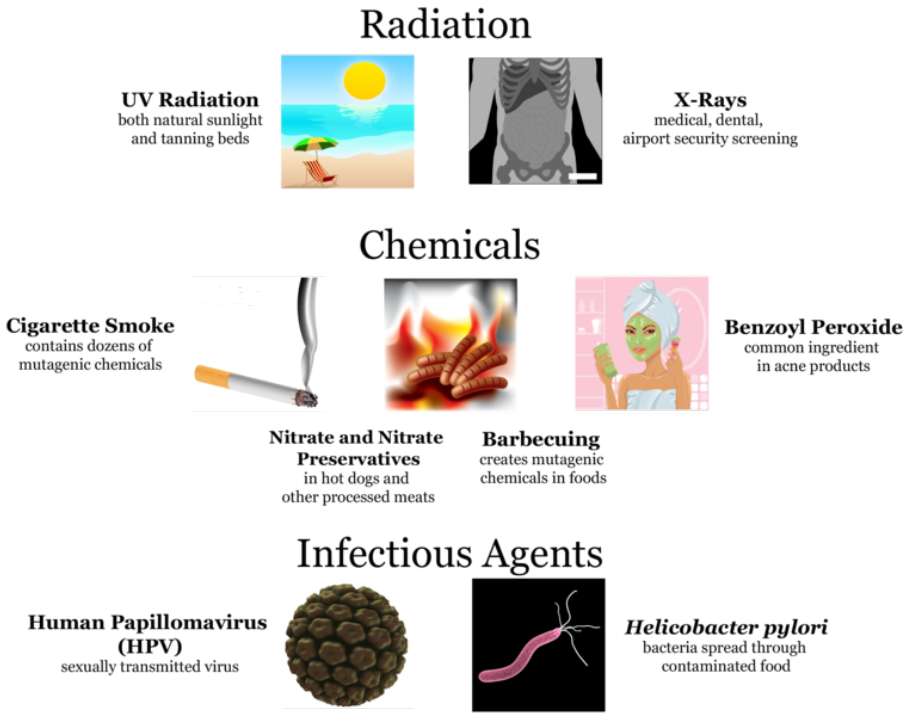


Mutations can happen for a variety of reasons.

Errors made during the copying of DNA

When a cell divides, it must copy its entire DNA. Sometimes the copy is not quite perfect. That small difference from the original DNA sequence is a mutation.

Environmental factors



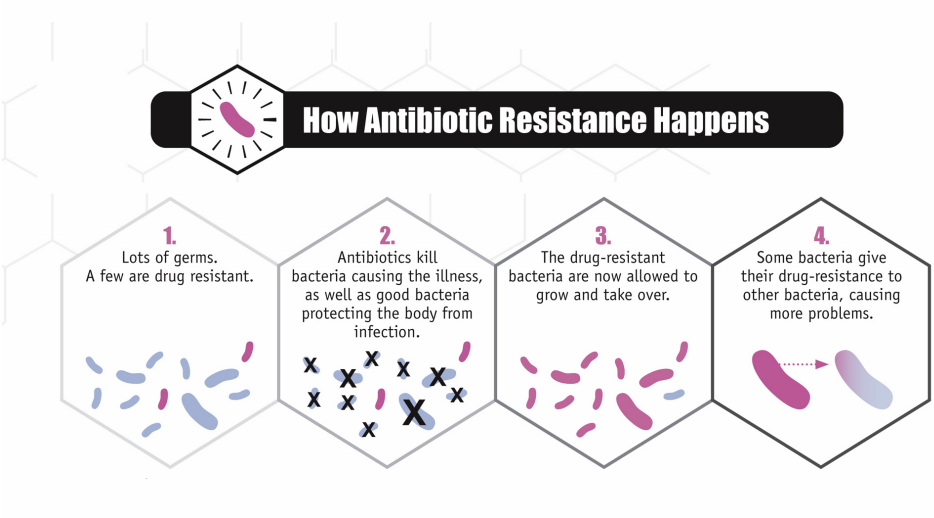
Mutations can also be caused by exposure to specific chemicals or radiation.

These are called mutagens.

When the cell repairs the DNA, it might not do a perfect job of the repair. So the cell would end up with DNA slightly different than the original DNA and hence, a mutation

Neutral Mutations

Also called silent mutations. These have little or no effect on the organism's ability to survive and reproduce.



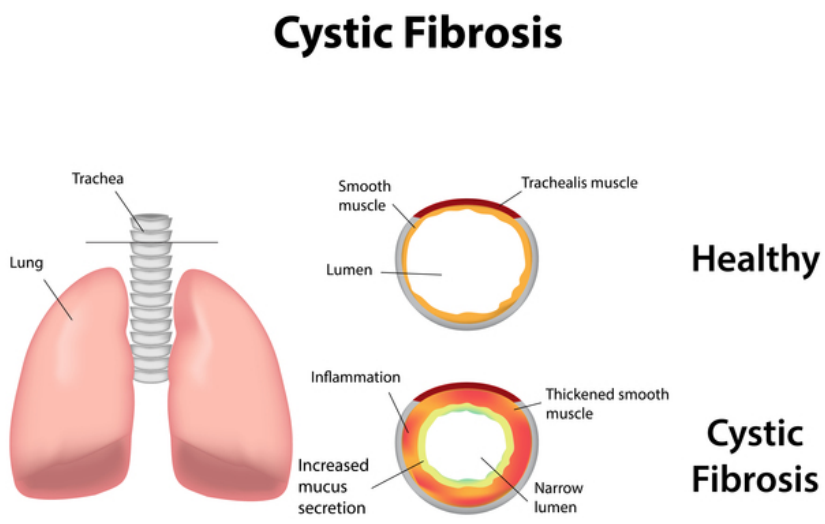
Positive Mutations

A positive mutation offers an advantage to an organism that may be passed on.

Examples include drug resistance in bacteria and disease resistance in humans

Negative Mutations

A mutation that causes disease or otherwise makes it difficult for the organism to survive.



CF is caused by a mutation in the gene cystic fibrosis transmembrane conductance regulator (CFTR). The most common mutation, ΔF508, is a deletion (Δ signifying deletion) of three nucleotides that results in a loss of the amino acid phenylalanine at the 508th position on the protein. This mutation accounts for two-thirds of CF cases worldwide and 90% of cases in the United States; however, there are over 1500 other mutations that can produce CF. Although most people have two working copies (alleles) of the CFTR gene, only one is needed to prevent cystic fibrosis. CF develops when neither allele can produce a functional CFTR protein. Thus, CF is considered an **autosomal recessive disease.**

On the line provided, write the letter of the term from the list that matches each description. Some can be used once, more than once, or not at all.

___1. disorder that causes a rapid breakdown of the nervous system beginning at age 2 or 3

___2. process that takes place when a c'some pair fail to separate correctly during meiosis

___3. form of trisomy in which there is an extra copy of c'some 21

___4. disorder that results in lack of pigment in hair or skin

___5. disorder caused by a recessive allele on c'some 7 that results in fluid buildup in the lungs

___6. Condition that exists when an individual is born with cells that contain 3 copies of a c'some

___7. genetic disorder known as PKU, for which newborn infants in PA are tested

___8. process that occurs during meiosis when pieces of c'somes break off and are lost

___9. disorder for which symptoms typically don't appear until late 30s or 40s

___10. nervous system disorder that is most prevalent in Jewish and French Canadian populations

___11. metabolic disease that if untreated can damage the nervous system

___12. disease in which a skin spots may develop into tumors

___13. disease that occurs mostly in males; when part of the X c'come may be deleted

a. albinism

b. cystic fibrosis

c. Tay-Sachs disease

d. phenylketonuria

e. Huntington disease

f. nondisjunction

g. trisomy

h. Down syndrome

i. neurofibromatosis

j. fragile-X syndrome

k. deletion

Lesson 5: Evolution

Evolution is the study of the natural forces and biological mechanisms that have shaped all living things on Earth.

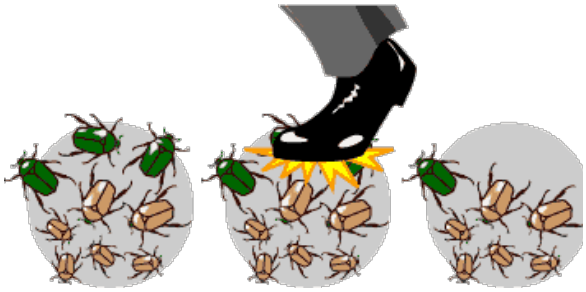
Some of the main mechanisms of evolution include Genetic Drift and Natural Selection:

Genetic Drift

Genetic drift refers to the change in the types of genes in a population because of the random nature of reproduction or in response to random events.

In other words, when people who have the gene causing a specific genetic trait reproduce with people who do not have the gene, the gene can become more prevalent or totally disappear from the population.

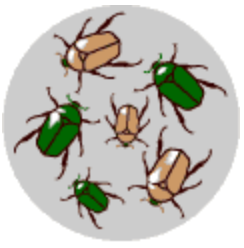
Eg. 1: A man steps on a group of beetles, randomly killing most of the green ones but leaving most of the brown ones alive, which results in fewer green alleles and thus green beetles being produced in the population.



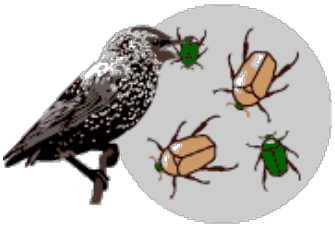
Eg. 2: Due to random successions of births, a town has an unusually high population of people with strawberry blonde hair, a trait that increases over time and leaves very few people with different hair colors.

Natural Selection

The process whereby organisms become better adapted to their environment allowing them to survive and produce more offspring. This can be seen with an example:

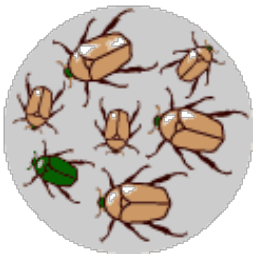


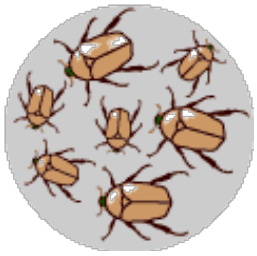
There is variation in traits. For example, some beetles are green and some are brown.



Green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do.

The surviving brown beetles have brown baby beetles because this trait has a genetic basis.





The more advantageous trait, brown coloration, which allows the beetle to have more offspring, becomes more common in the population. If this process continues, eventually, all individuals in the population will be brown.

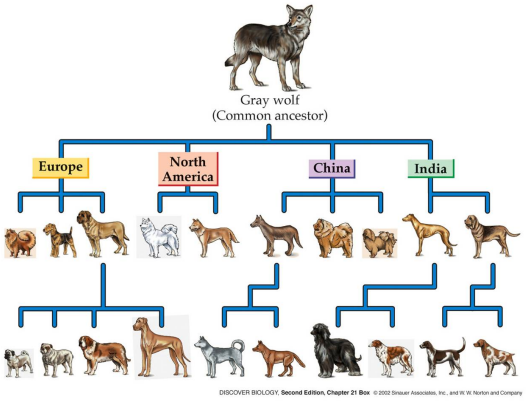
What are the 4 main principles of natural selection?

The five principles of natural selection are typically described as follows:

1. Most characteristics in the population must be inherited.
2. More offspring must be produced than can survive.
3. The fittest offspring must be more likely to survive and reproduce.
4. There must be genetic variation that allows for the best traits to be selected.

Artificial Selection

The intentional reproduction of individuals in a population that have desirable traits. In organisms that reproduce sexually, two adults that possess a desired trait — such as two parent plants that are tall — are bred together.



Invasive Species

An invasive species is a plant, fungus, or animal species that is not native to a specific location (an introduced species), that has a trait that provides an advantage over local species. This causes harm to local species.

Eastern Grey Squirrel

Scotch Broom

Giant Hogweed

Worksheet: Darwin's Natural Selection

Read the following situations below and identify the 4 points of Darwin's natural selection.

1) There are 2 types of worms: worms that eat at night (nocturnal) and worms that eat during the day (diurnal). The birds eat during the day and seem to be eating ONLY the diurnal worms. The nocturnal worms are in their burrows during this time. Each spring when the worms reproduce, they have about 500 babies but only 100 of these 500 ever become old enough to reproduce.

a. What worm has natural selection selected AGAINST? _____ FOR? _____
b. What is the selective pressure? _____

c. Darwin's 4 points: Identify the 4 points in the scenario above.

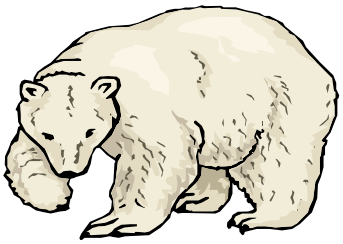
Populations have variations. _____

More offspring are produced than survive. _____

Those that survive have favourable traits. _____

A population will change over time. _____

2) There are 3 types of polar bears: ones with thick coats, ones with thin coats and ones with medium coats. It is fall, soon to be winter. The temperatures are dropping rapidly and the bears must be kept warm, or they will freeze to death. Many of the bears have had ~2 cubs each but due to the extreme temperatures, many mothers only have one cub left.



a. What bear will natural selection select AGAINST? _____FOR? _____
b. What is the selective pressure? _____

c. Darwin's 4 points: Identify the 4 points in the scenario above.

Populations have variations. _____

More offspring are produced than survive _____

Those that survive have favourable traits. _____

A population will change over time.

_____

3) In ostriches, there are 2 types: ones that run fast and those that run slowly. The fast birds can reach up to 40 miles an hour. Jackals love to eat ostrich, and they can reach speeds of up to 35-40 miles per hour. A flock of ostrich will lay ~ 10 eggs (each mother only lays but many rodents break into the eggs and eat the fetus before they hatch.

a. What ostrich will natural selection select AGAINST? _____ FOR? _____
b. What is the selective pressure? _____

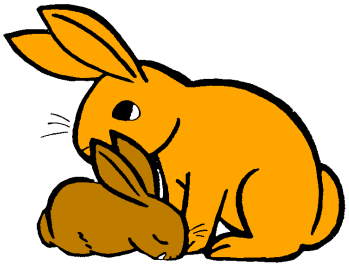
c. Darwin's 4 points: Identify the 4 points in the scenario above.

Populations have variations. _____

More offspring are produced than survive. _____

Those that survive have favourable traits. _____

A population will change over time. _____



4) There are two types of rabbits: those that strictly eat grass and those that strictly eat berries and flowers. A drought occurs one year, and the plants have difficulty producing any extras (flowers, berries, etc.). They can only try and keep themselves green. The rabbits have had babies all year long but many are eaten by foxes or hawks Due to the drought, many have starved to death.

a. What rabbit will natural selection select AGAINST? _____FOR? _____
b. What is the selective pressure? _____
c. Darwin's 4 points: Identify the 4 points in the scenario above.

Populations have variations. _____

More offspring are produced than survive _____

Those that survive have favourable traits. _____

A population will change over time. _____

5) Bob believes that giraffes have long necks because they have stretched their necks to try and reach food that is high in trees. Since the parent had stretched its neck, it passed the long neck on to its offspring.

b. Ryan believes that giraffes have long necks because the ones with long necks were able to reach the food, and those with short necks could not and died. The long necked giraffes reproduced, and soon all of the giraffes had long necks.

a. Who thinks like Lamarck? **Bob**

b. Who thinks like Darwin? **Ryan**

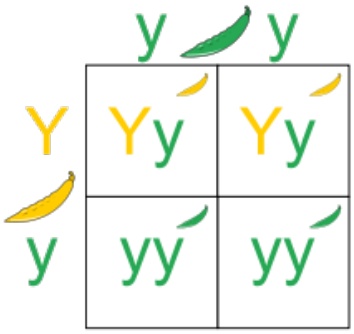
Lesson 6: Heredity

Mendelian Genetics

Gregor Johann Mendel (20 July 1822 – 6 January 1884) was a German scientist and Augustinian friar who gained posthumous fame as the founder of modern genetics.

Mendel grew pea plants and observed several traits often associated with pea plants such as height and colour. He bred plants with different traits together and made careful measurements of the traits found in the offspring.

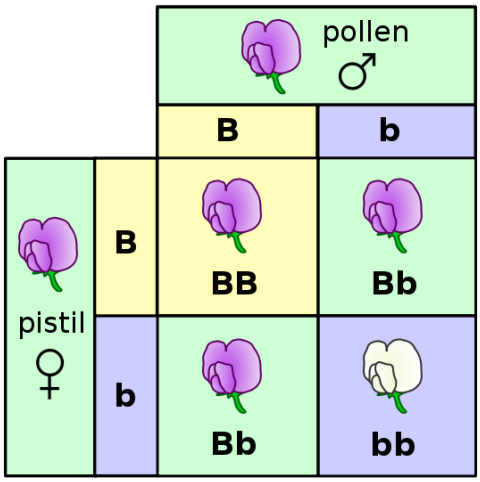
Mendel coined the terms "recessive" and "dominant" in reference to certain traits. We now use these terms to describe genes.



Colour in pea plants is controlled by a gene that occurs in two varieties or alleles. They are represented by the letters Y (yellow) and y (green). Each parent contributes only a single copy of this gene to its offspring which gives rise to the following probabilities:

Y (yellow) is the dominant allele, which means that all offspring that get this allele will be yellow in colour, even if the other allele is the recessive y (green).

This is known as **complete dominance**.



Genotype refers to the letters or alleles present. ie. Yy

Phenotype refers the physical expression of the alleles. ie. Yellow plants

Homozygous means both alleles are the same for that particular gene. ie. Homozygous dominant (YY) or homozygous recessive (yy)

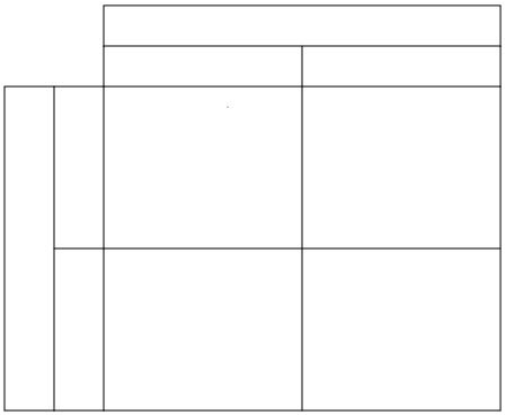
Heterozygous means different alleles are present for that particular gene. (Yy)

Sample problems involving **Complete Dominance:**

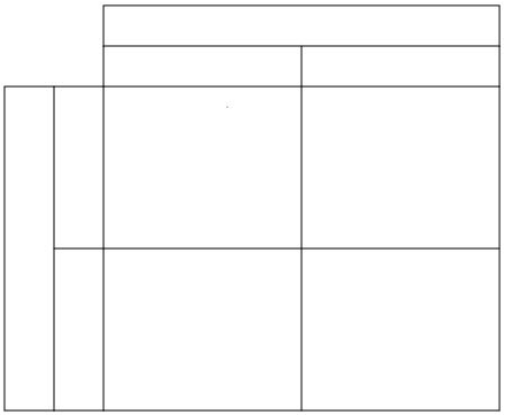
1) In seals, the gene for the length of the whiskers has two alleles. The dominant allele (W) codes long whiskers & the recessive allele (w) codes for short whiskers.

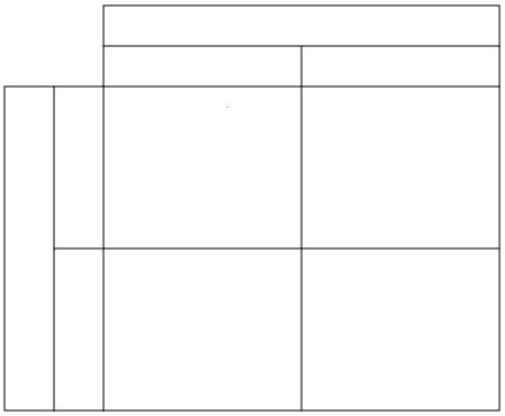
a) What percentage of offspring would be expected to have short whiskers from the cross of two long-whiskered seals, one that is homozygous dominant (WW) and one that is heterozygous? (Ww)

b) If one parent seal is pure long-whiskered and the other is short-whiskered, what percent of offspring would have short whiskers?



2) Tail length in cats is caused by a dominant allele (T) which gives a cat a long tail. If a long tailed homozygous dominant male cat mates with a short tailed female cat what will all their kittens look like? What if two of their kittens mature and mate with one another, what will be their offspring look like with respect to tail length?





3) If two short tailed cats mated and all of their offspring had short tails what can you say about the genotype of the two parents?

4) Could a long tailed cat ever have an offspring that had a short tail?

1. Define Genetics and Heredity?

2. What is the difference between the dominant and recessive forms of alleles?

3. Define the terms homozygous, heterozygous, genotype and phenotype.

4. Draw Punnett squares for the crosses below. State the ratio of the genotype produced.

AA x aa

	A	A
a		
a		

Rr x Rr

	R	r
R		
r		

TT x Tt

	T	T
T		
t		

5. In humans, the allele that codes for an ability to taste PTC is dominant (T), and the allele that codes for an inability to taste this chemical is recessive (t). A male who is heterozygous for this trait marries a female who cannot taste PTC.
   a. What are the genotypes of the male and female?

   b. Draw a Punnett square to show the possible genotypes of their offspring.

	T	t
t		
t		

   c. What is the predicted percentage of their offspring that will be able to taste PTC?

   d. What is the percentage that will not be able to taste PTC?

6. Human eye color is inherited as brown eyes are dominant and blue eyes are recessive. Use Punnett squares to solve the following problems. Pick your own letters to represent eye color traits.

    a. A man with blue eyes marries a woman with brown eyes, whose mother had blue eyes. What proportion of the children would be expected to have blue eyes?

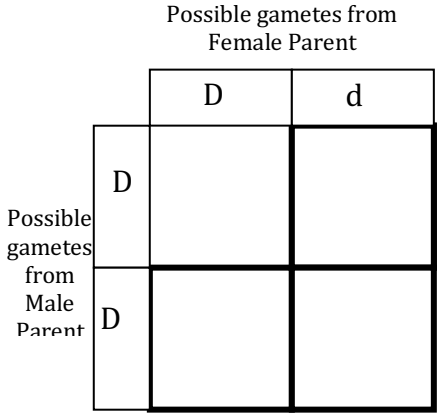
    b. A brown eyed man marries a blue eyed woman. The first child is blue eyed. What is the man's genotype?

7. A father is who is ***homozygous dimpled***, and a mother who is ***heterozygous dimpled*** have children.

    a) Show the two alleles carried by the father. (Use "D" for dimpled and "d" for smooth)

    b) Show the two alleles carried by the mother. (Use "D" for dimpled and "d" for smooth)

    c) Fill in the following Punnett Square showing the cross and show the combinations of genes possible in the children.



    d) According to chance, what fraction of their children will have dimples?

    e) What fraction of the children should be ***homozygous smooth***? (if any)

    f) What fraction of the children should be ***heterozygous dimpled***? (if any)

    g) What fraction of the children should be ***homozygous dimpled***? (if any)

Lesson 7: Non-Mendelian Inheritance

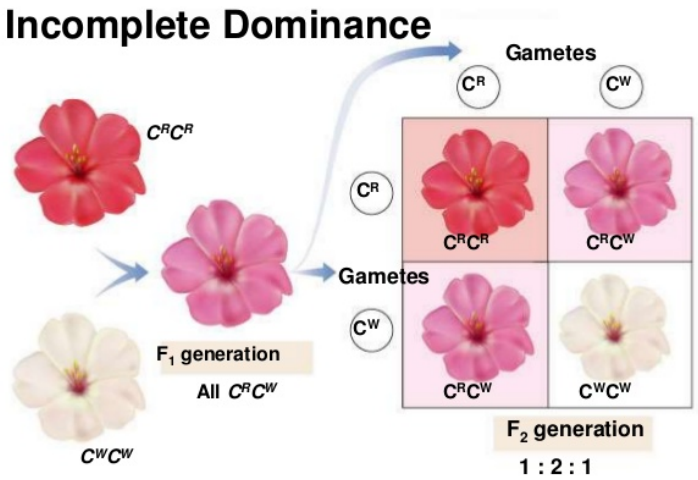
Phenotype	Red	Pink	White
Genotype	RR	Rr	rr

Incomplete Dominance

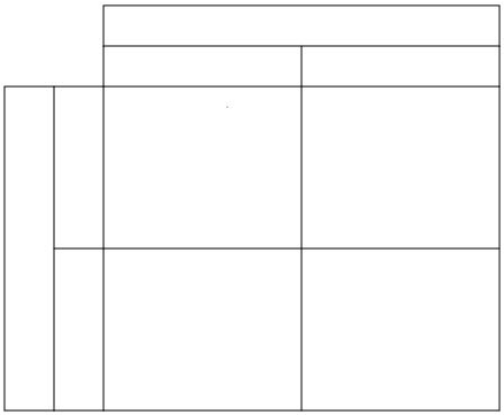
Incomplete dominance is when one allele is only slightly dominant over the other. This results in the heterozygous genotype having a phenotype that is a blend of the two different homozygous types.

A good example of this is colour in Carnations.

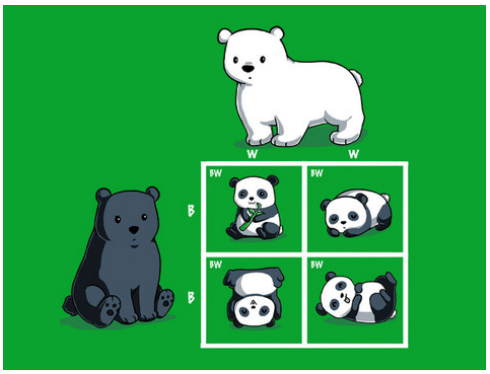
The letters used to represent the alleles that show incomplete dominance are often represented with only capital letters because neither trait is dominant over the other.



Eg. 1: In roses, petal colour is controlled by a gene with two alleles, W for white and w for red. W shows incomplete dominance over w. What will be the percentages of each colour offspring produced if two pink roses are crossed?



Codominance



Codominance is when each allele is equally dominant. This results in the heterozygous genotype displaying both phenotypes at the same time.

An example of codominance: Inheritance of A, B, AB and O blood group.

In humans, there are 4 blood types (phenotypes): A, B, AB, and O. Blood type is controlled by **3 alleles**: I^A, I^B, I^O (the base letter = I stands for immunoglobulin)

- I^O is **recessive**, two I^O alleles must be present for the person to have type O blood
- I^A and I^B are **codominant** but both are dominant to I^o. If a person receives an I^A allele and a I^B allele, their blood type is type AB, in which characteristics of both A and B antigens are expressed.

Blood type	Genotype	
A	I^A, I^O I^A, I^A	AO AA
B	I^B, I^O I^B, I^B	BO BB
AB	I^A, I^B	AB
O	I^O I^O	OO

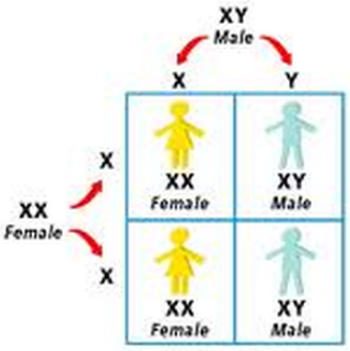
Blood Type Problem

Three children recently born in a hospital were accidently mixed up. The blood types of the parents involved are given along with the blood types of the infants. Determine which baby belongs with which parents, and explain your reasoning for the decisions you made.

Mother and Father		Babies	
Parents #1	Type A & Type B	Child x	Type A
Parents #2	Type O & Type AB	Child y	Type O
Parents #3	Type B & Type O	Child z	Type AB

- Because I^O is dominant to both I^A and I^B alleles, a person with blood group A could have the genotype I^A I^O or I^A I^A. This has implication when having children because, if both parents carry the I^O allele, a child could be born with the genotype I^OI^O (blood group O), even though neither of the parents have this phonotype.

Sex Linked Inheritance



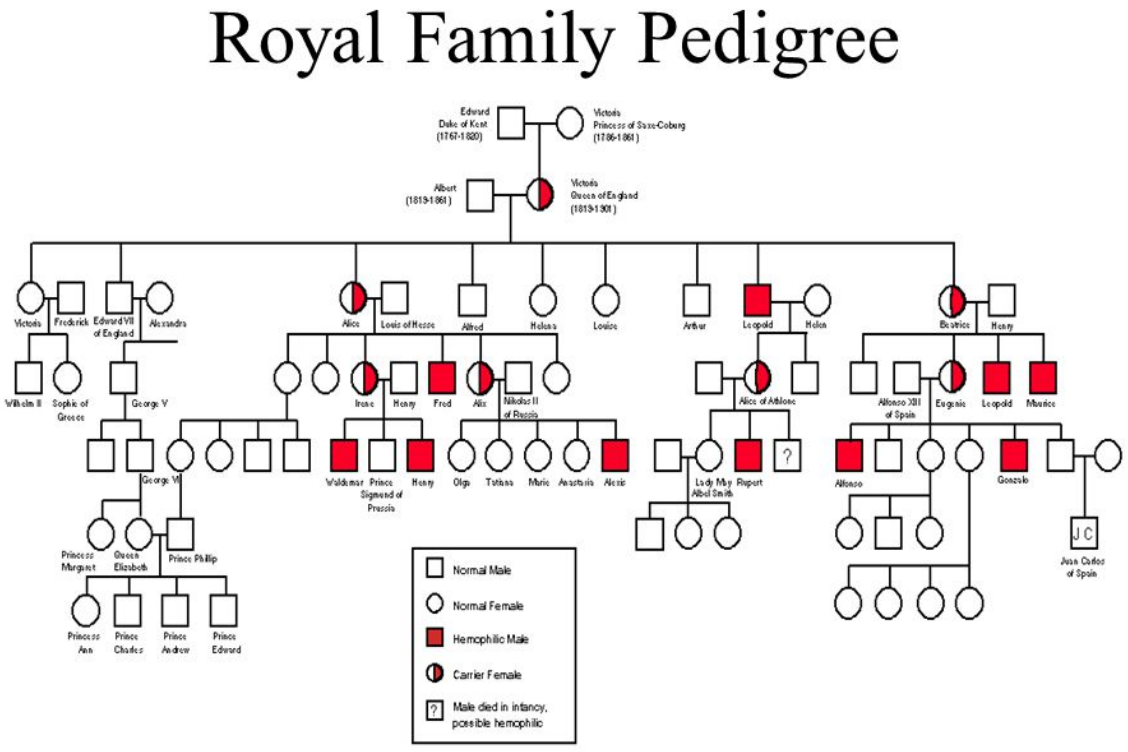
If a gene is found only on the X chromosome and not the Y chromosome, it is said to be a **sex-linked trait**. Diseases caused by defective genes of the X chromosome tend to afflict males more than females.

Why?

Hemophilia is a bleeding disorder that slows the blood clotting process. People with this condition experience prolonged bleeding or oozing following an injury, surgery, or having a tooth pulled. In severe cases of hemophilia, continuous bleeding occurs after minor trauma or even in the absence of injury (spontaneous bleeding). Serious complications can result from bleeding into the joints, muscles, brain, or other internal organs. Milder forms of hemophilia do not necessarily involve spontaneous bleeding, and the condition may not become apparent until abnormal bleeding occurs following surgery or a serious injury.

Hemophilia is caused by a faulty gene located on the X chromosome and as a result, males typically are most commonly afflicted. Females tend to be carriers of the disease.

Other Sex linked conditions include red-green color blindness and male pattern baldness.



Human blood types are determined by genes that follow the **CODOMINANCE** pattern of inheritance. There are two dominant alleles (A & B) and one recessive allele (O).

Blood Type (Phenotype)	Genotype	Can donate blood to:	Can receive blood from:
O	ii (OO)	A,B,AB and O (universal donor)	O
AB	I^AI^B	AB	A,B,AB and O (universal receiver)
A	I^AI^A or I^Ai (I^AO)	AB, A	O,A
B	I^BI^B or I^Bi (I^BO)	AB,B	O,B

1. Write the genotype for each person based on the description:
   a. Homozygous for the "B" allele _____
   b. Heterozygous for the "A" allele _____
   c. Type O _____
   d. Type "A" and had a type "O" parent _____
   e. Type "AB" _____
   f. Blood can be donated to anybody _____
   g. Can only get blood from a type "O" donor _____

2. Complete the punnett square showing all the possible blood types for the offspring produced by a type "O" mother and an a Type "AB" father. **What are percentages of each offspring?**

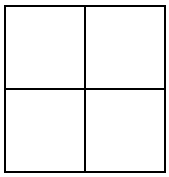
3. Mrs. Essy is type "A" and Mr. Essy is type "O." They have three children named Matthew, Mark, and Luke. Mark is type "O," Matthew is type "A," and Luke is type "AB." Based on this information:

   a. Mr. Essy must have the genotype _____

   b. Mrs. Essy must have the genotype _____ because _____ has blood type _____

   c. Luke cannot be the child of these parents because neither parent has the allele _____.

4. Two parents think their baby was switched at the hospital. Its 1968, so DNA fingerprinting technology does not exist yet. The mother has blood type "O," the father has blood type "AB," and the baby has blood type "B."



   a. Mother's genotype: _____

   b. Father's genotype: _____

   c. Baby's genotype: _____ or _____

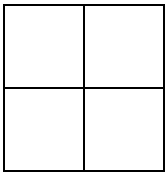
   d. Punnett square showing all possible genotypes for children produced by this couple.

   e. Was the baby switched? _____

5. Based on the information in this table, which men **<u>could not</u>** be the father of the baby?

   *(hint… look at the baby's blood type only…)*_____
   You can use the Punnett square if you need help figuring it out.

Name	Blood Type
Mother	Type A
Baby	Type B
The mailman	Type O
The butcher	Type AB
The waiter	Type A
The cable guy	Type B



6. A women went on a daytime TV show to identify the father of her child. She had the show give blood tests of potential fathers. Based on the information in this table, why was the baby taken away by government officials after the episode aired?

   *(hint… look at the baby's blood type only…)*_____

Name	Blood Type
Mother	Type O
Baby	Type AB
Bartender	Type O
Guy at the club	Type AB
Cab driver	Type A
Waiter	Type B

7. In humans, hemophilia is a sex linked trait. Females can be normal, carriers, or have the disease. Males will either have the disease or not (but they won't ever be carriers)

$X^H X^H$ = female, normal

$X^H X^h$ = female, carrier

$X^h X^h$ = female, hemophiliac

$X^H Y$ = male, normal

$X^h Y$ = male, hemophiliac

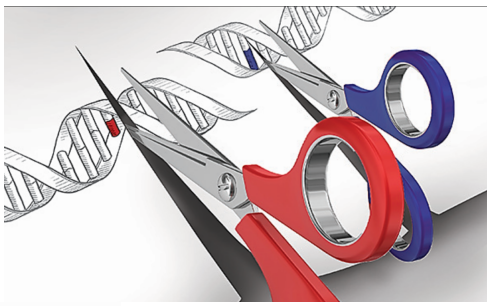
Show the cross of a man who has hemophilia with a woman who is a carrier.

What is the probability that their children will have the disease? _____

A woman who is a carrier marries a normal man. Show the cross. What is the probability that their children will have hemophilia? What sex will a child in the family with hemophilia be?

A woman who has hemophilia marries a normal man. How many of their children will have hemophilia, and what is their sex?

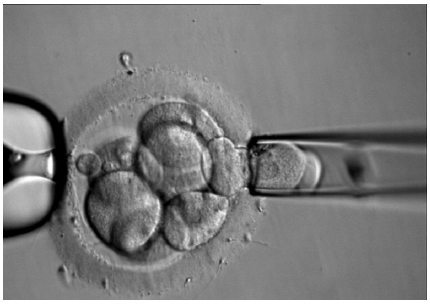
Lesson 8: Applications of Genetics



Modern genetic science has transformed how we grow crops, treat disease and understand the very nature of life.

But it also comes with some concerns that must be weighed carefully.

Embryo Screening

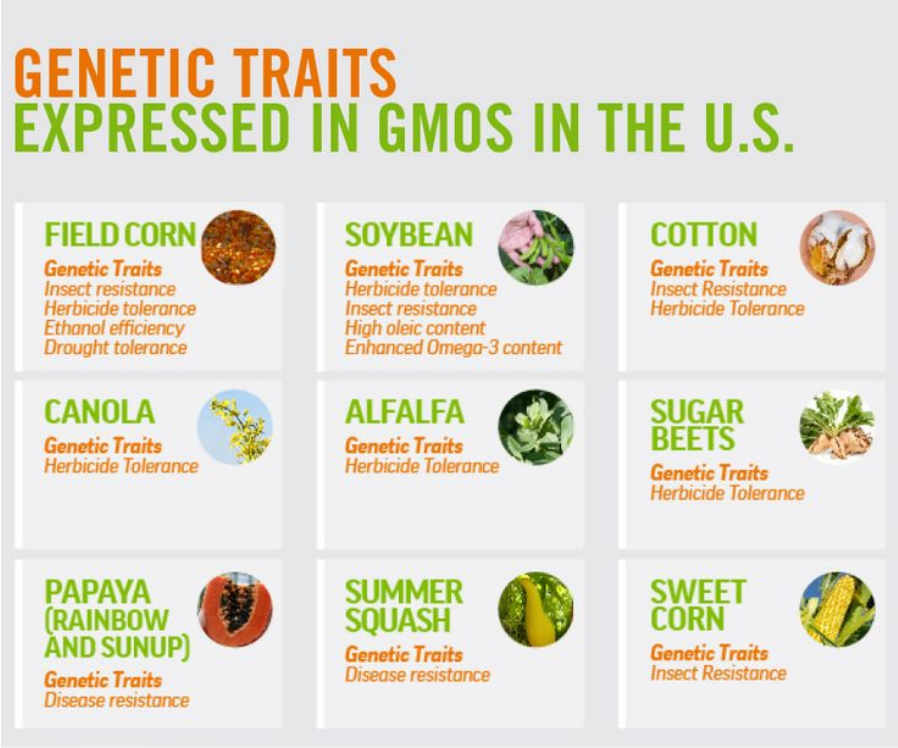


PGD, Pre-Implanted Genetic Diagnosis is a process that allows doctors to screen multi-cellular embryos for a multitude of genetic disorders and diseases. In theory, if the genetic cause of either a disease or undesirable trait can be identified it can be removed or changed.
Eg. Huntington's disease.

Concerns about this technology include the possibility that someone will create babies with specific traits and or gender.

Genetically Modified Organisms (GMOs)

A genetically modified organism (GMO) is any organism
whose genetic material has been altered using genetic engineering.



GMOs are used to produce many medications and genetically modified foods.

They are widely used in scientific research and the production of other goods.

However, many people have concerns about the use of GMO's because of:

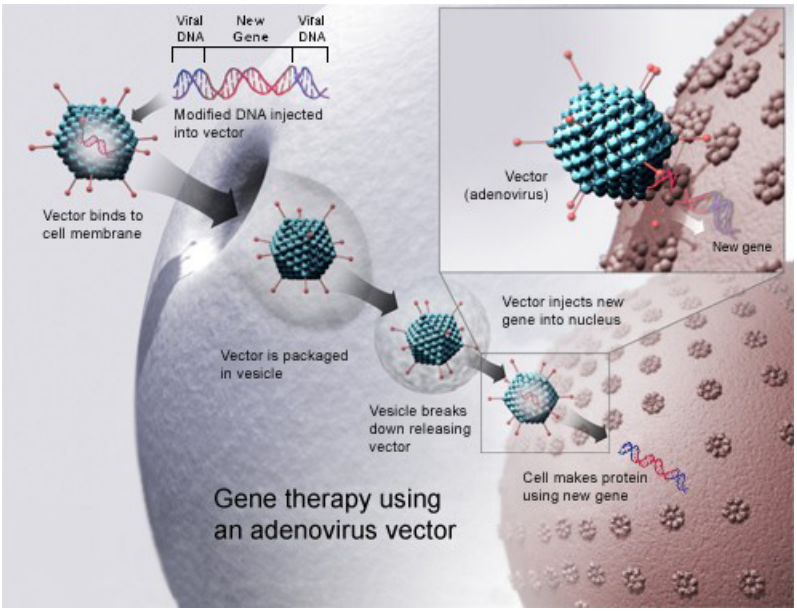
- General distaste for what is considered manufactured food rather then natural food.
- Because the companies that manufacture GMOS have been associated with chemical weapons and globalization.
- Concern regarding biodiversity and the fear that a single disease could wipe out the vast majority of a crop.
- People love a good conspiracy theory.
- The perception of bias of those paying for studies that support or refute the safety of GMO's.
- Concern regarding the development of super pests. Reliance on single herbicides or insecticides (such as Roundup) results in rapid pest evolution to be tolerant to it.

Gene Therapy

Gene therapy is an experimental technique that uses genes to treat or prevent disease. In the future, this technique may allow doctors to treat a disorder by replacing a missing or defective gene in a patient's cells instead of using drugs or surgery. Researchers are testing several approaches to gene therapy, including:

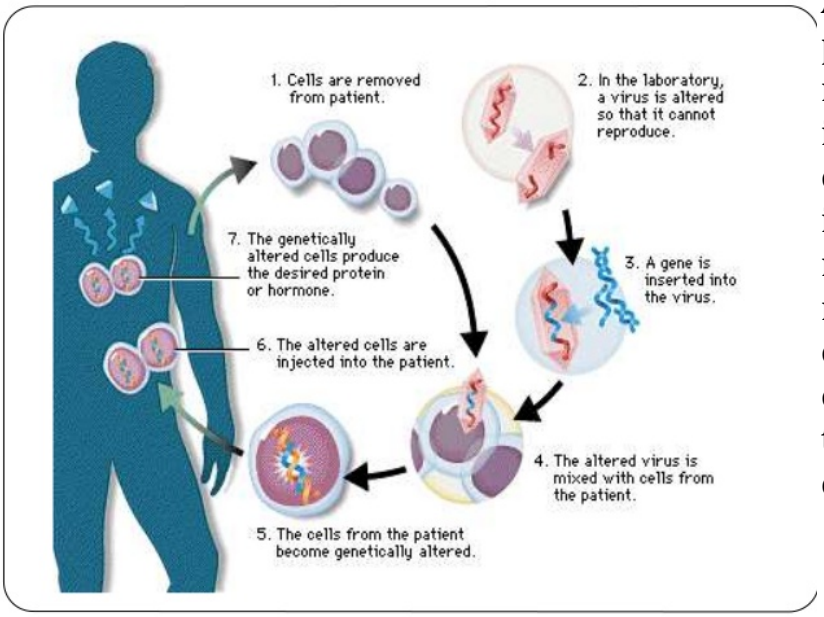
- Replacing a mutated gene that causes disease with a healthy copy of the gene.
- Inactivating, or "knocking out", a mutated gene that is functioning improperly.
- Introducing a new gene into the body to help fight disease.

A gene that is inserted directly into a cell usually does not function because it hasn't been integrated into the cells DNA. In order for the gene to be integrated, a carrier called a vector is used to deliver the gene. Certain viruses are often used as vectors because they can deliver the new gene by infecting the cells. The viruses are modified they can't cause disease when used in people. The vector can be injected or given intravenously (by IV) directly into a specific tissue in the body, where it is taken up by individual cells.



Alternatively, a sample of the patient's cells van be removed and exposed to the vector in a laboratory setting. The cells containing the vector are then returned to the patient. If

the treatment is successful, the new gene delivered by the vector will make a functioning protein.



Although gene therapy is a promising treatment option for a number of diseases (including inherited disorders, some types of cancer, and certain viral infections), the technique remains risky and is still under study to make sure that it will be safe and effective. As such, gene therapy is currently only being tested for the treatment of diseases that have no other cures.

Because gene therapy involves making changes to the body's set of basic instructions, it raises many unique ethical concerns.

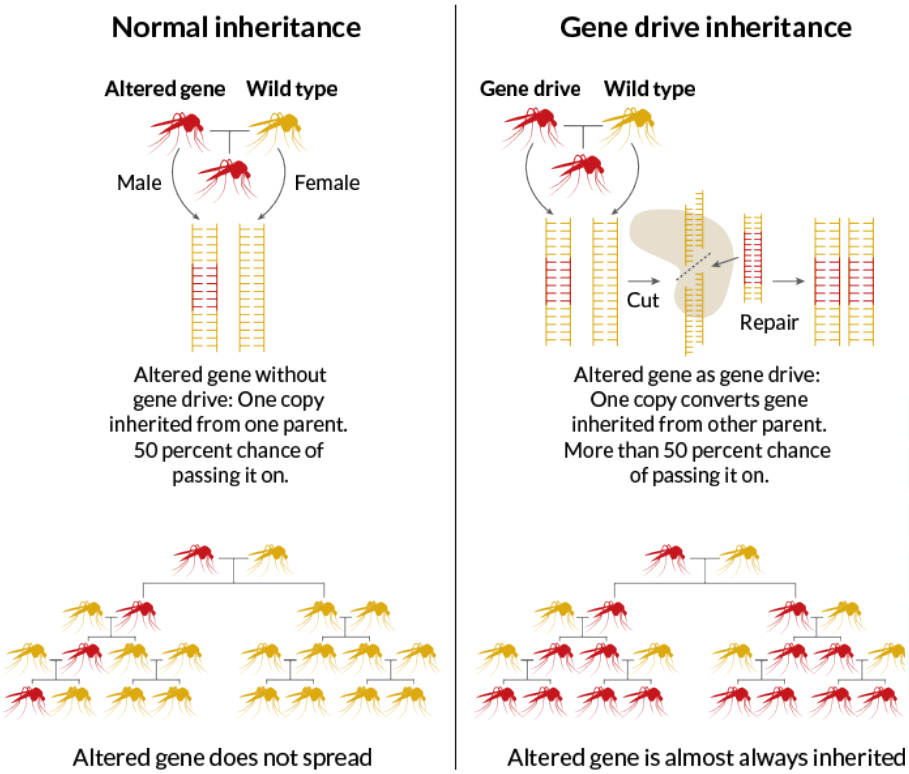
What do you think are some ethical questions that surround gene therapy?

- How can we distinguish between "good" and "bad" uses of gene therapy?
- Who decides which traits are normal and which constitute a disability or disorder?
- Considering the high costs of gene therapy, will it be available to everyone? Or only those who can afford it?
- Could the widespread use of gene therapy make society less accepting of people who are different?
- Should people be allowed to use gene therapy to enhance basic human traits such as height, intelligence, or athletic ability?

How would you answer these difficult questions?

CRISPR-Cas9

CRISPR-Cas9 is a genome-editing tool that is creating a buzz in the science world. It is faster, cheaper and more accurate than previous techniques of editing DNA and has a wide range of potential applications.



CRISPR-Cas9 is a unique technology that enables geneticists and medical researchers to edit parts of the genome by cutting out, replacing or adding parts to the DNA sequence.

It is currently the simplest, most versatile and precise method of genetic manipulation and is therefore causing a buzz in the science world.