Chapter 11

Genetics

What is Genetics?

Genetics comes from the word - GENE.
Genes are sections on **chromosomes** that code for a specific trait. They are found in the nucleus of every cell in your body. They are made of **DNA (deoxyribonucleic acid)**. You inherit genes from your parents. (the egg and the sperm)

Traits

Every organism is a collection of traits. A trait is an inherited characteristic. All traits are inherited from parents.

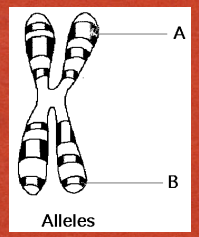
Heredity

Passing of traits from parent to offspring.

traits are controlled by genes. (**Genes** are a section of **DNA** on a chromosome that codes for a specific trait - making of specific proteins.)

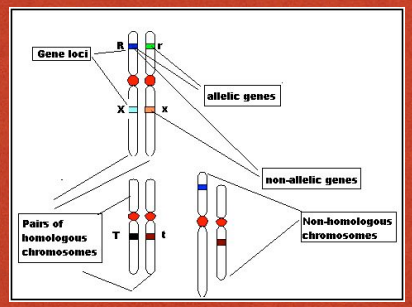
During meiosis (which is the division of the cell nucleus to produce sex cells called **gametes)** chromosomes separate into each of the male and female gametes.

Pairs of genes also separate from one another. As a result , each gamete winds up with one form of a gene for each trait that an organism displays.



ALLELES

the different forms a gene may have for a trait



When genes separate during meiosis, alleles for each trait also separate into different gametes.

Genetics - the study of how traits are inherited through the interactions of alleles

Gregor Mendel

*an Austrian monk in 1800's, university educated

*know as the **Father of Genetics**

*responsible for the first scientific study of how traits pass from one generation to the next

*like many scientist, Mendel's work was not understood until after his death.

Mendel performed his experiments with ordinary green pea plants.

Pea plants are easy to breed for pure traits and grow relatively quickly.

Table 14.1 The Results of Mendel's F_1 Crosses for Seven Characters in Pea Plants [true breeding: itself × itself]

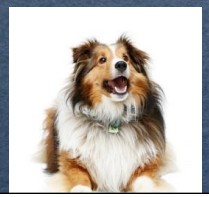
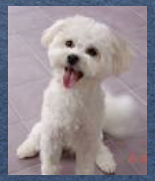
Character	Dominant Trait	×	Recessive Trait	F_2 Generation Dominant:Recessive	Ratio
Flower color	Purple	×	White	705:224	3.15:1
Flower position	Axial	×	Terminal	651:207	3.14:1
Seed color	Yellow	×	Green	6022:2001	3.01:1
Seed shape	Round	×	Wrinkled	5474:1850	2.96:1
Pod shape	Inflated	×	Constricted	882:299	2.95:1
Pod color	Green	×	Yellow	428:152	2.82:1
Stem length	Tall	×	Dwarf	787:277	2.84:1



Purebred

An organism that always produces the same traits in its offspring.

If you are a breeder - purebreds will usually make the seller more money because of the pure traits of the animal.

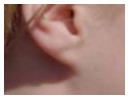



Each time Mendel studied a trait, he crossed two plants with different expressions of the trait and looked to see which trait would be expressed in the offspring. Because these new plants received different genetic information, or alleles, from each parent he called them **hybrids**.

Mendel used cross-pollination to cross purebred tall plants with purebred short plants (pollinated by hand) All tall plants were produced. The allele that caused short plants seemed to disappear,yet Mendel knew it had to be there.

Mendel called the tall form the **dominant** factor, because it seemed to dominate or cover up the short height form of the allele. The dominate factor is alway represented by a capital letter. (EX. T = tall)

Mendel called the short form, the form that seemed to disappear, the recessive factor. The recessive trait is always represented by a lower case letter. (EX. t = short)

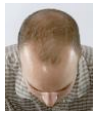







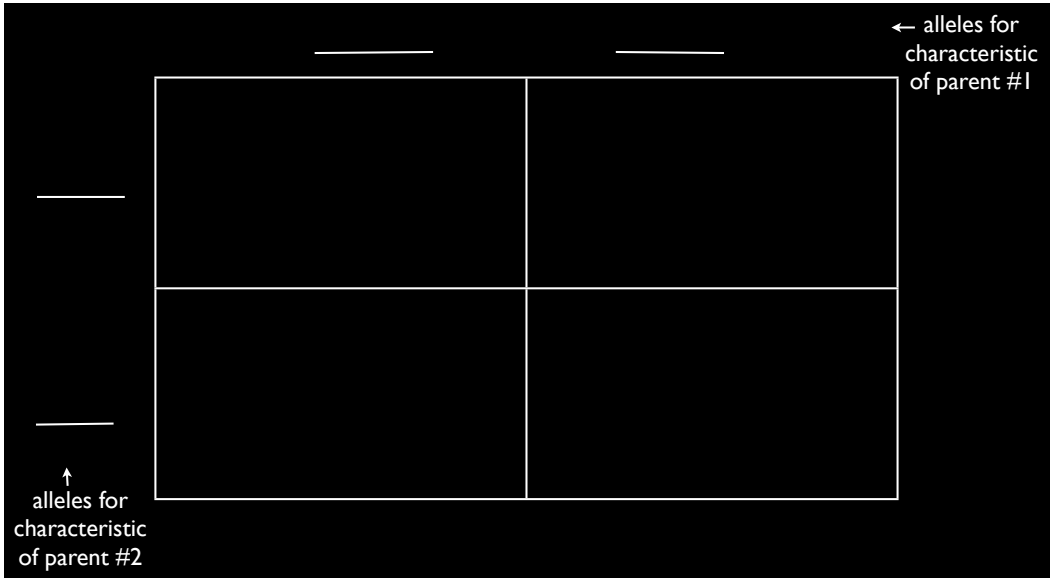






Mendel let the new tall plants cross-pollinate - the offspring were both tall and short. Mendel noticed that for every three tall plants there was one short plant, or a 3:1 ratio. These results were repeated time and time again. Mendel knew that the probability was great that he would get the same outcome each time.

Probability - the science that helps you determine the chance that something will take place.



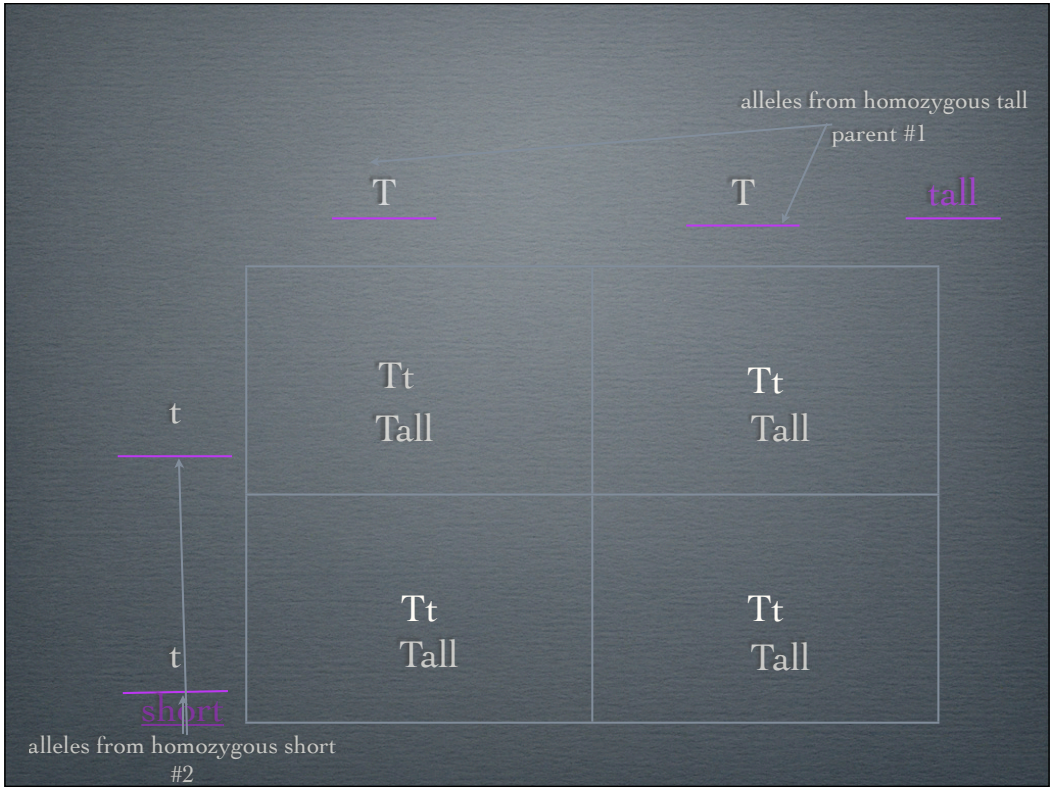
A handy tool used to predict probability is the Punnett Square.

The letters show the genetic makeup, or the **genotype**, of an organism. The genotype for all the offspring in the above cross is Tt.

The physical trait that shows as a result of a particular genotype is its **phenotype.** All of the offspring in the above cross are tall. The phenotype describes the appearance of a trait in an organism.

Every cell in your body has two alleles (at least - some more) for every trait. An organism with two alleles for a trait that are exactly the same is called **homozygous.** EX. TT, tt

An organism that has two different alleles for a trait is called **heterozygous.** EX. Tt


alleles from homozygous tall parent #1
T
T
tall
t
t
short
Tt
Tall
Tt
Tall
Tt
Tall
Tt
Tall
alleles from homozygous short #2

RULES FOR USING PUNNETT SQUARES

1. Place parent #1 (1st parent listed - mom) across the top of the Punnett square and parent #2 (2nd parent listed - dad) along the left side of the Punnett square. Always give the phenotype of each parent.

2. Capital letter (dominant trait) is always written first when writing the genotype of a heterozygous individual. EX. = Tt

3. If there is more than one trait represented or multiple letters being used, always list the letters alphabetically. EX. =RW or RR'

4. List the genotype (EX. = Tt) of each zygote and the phenotype (EX. = tall) of each zygote in each square of the Punnett square.

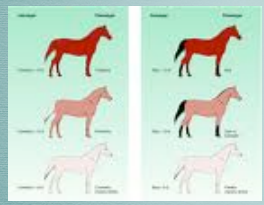
5. Be sure that everyone reading your Punnett square can clearly distinguish between lower case letters and uppercase letters. (EX. = Yy)
6. Always use the same letter to represent a single trait
capital letter= dominant trait (T = tall)
lower case letter = recessive trait (t = short)

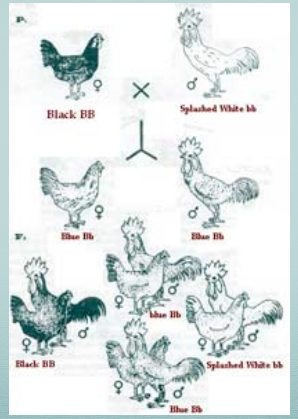
Summary of Mendalian iNheritance

1. traits are controlled by alleles on chromosomes.
2. An allele may be dominant or recessive in form.
3. When a pair of chromosomes separates during meiosis, the different alleles for a trait move into separate gametes.

INCOMPLETE DOMINANCE

In some cases, one allele is not dominant over the other. When both alleles are expressed in the offspring, the condition is called **incomplete dominance**.
When you have incomplete dominance, you will see a new phenotype in heterozygous offspring. EX: red four o'clock plant crossed with a white four o'clock plant = a pink four o'clock plant.
Just a few species that exhibit incomplete dominance include coat color in cattle and horses, feather color in some chicken breeds, flower color in many plants.




P.
Black BB
Splashed White bb
F1
Blue Bb
Blue Bb
Black BB
Blue Bb
Splashed White bb
Blue Bb

Example of Punnett square showing incomplete dominance

C = chestnut
C^1 = cremello
CC^1 = palomino

	C	C
C^1	CC^1 palomino horse	CC^1 palomino horse
C^1	CC^1 palomino horse	CC^1 palomino horse

chestnut horse

cremello horse

Example of Punnett square showing incomplete dominance

R = red flower
R^1 = white flower
RR^1 = pink flower

	R	R red flower
R^1 white flower	RR^1 pink flower	RR^1 pink flower
R^1	RR^1 pink flower	RR^1 pink flower

Multiple Alleles

Many traits have more than two alleles, or multiple alleles, that control them.

Human blood type has three alleles - A, B, and O.

A and B are both inherited by incomplete dominance. Both A and B are dominant over O, which is recessive.

Human Blood Types

	Phenotype	Genotype
Incomplete Dominance	A	I^AI^A, I^Ai
	B	I^BI^B, I^Bi
	AB	I^AI^B
Recessive	o	ii

POLYGENIC INHERITANCE

Many traits are a result of multiple genes, having multiple genes, having multiple alleles-on them, working together to produce a specific trait. Polygenic inheritance occurs when a group of gene pairs acts together to produce a trait.

Eye color, height, skin color, and hair color are all examples of traits produced by the combination of several different genes.
The environment plays a role in how traits are exhibited or expressed in living things.
EX. Some people have genes that make them at risk for certain cancers but they may be able to prevent the development of those cancers through their behavior. (people who have a family history of a particular disease may limit their risk factors - example - family history of skin cancers - people may limit sun exposure and wear sun screen routinely.)

Human Genes and Mutations

Occasionally errors occur in the DNA to be passed from cell to cell. Any permanent change in an organisms DNA is called a **mutation**.

Not all mutations are harmful, some may be beneficial.

Certain chemicals, xrays, and radioactive materials are some of the materials known to cause mutations.

Chromosome Disorders

In addition to individual mutations, problems can occur if an organism inherits an incorrect number of chromosomes. Every organism has a specific number of chromosomes - mistakes in meiosis can result in too many or too few chromosomes. This can result in serious problems, but usually is fatal.

EX. Down's Syndrome - 3 copies of chromosome 21

Klinefelter's Syndrome - sex chromosomes (pair 23) is XXY instead of XX or XY

super female syndrome - sex chromosomes (pair 23) are XXX

Turner syndrome - sex chromosomes (pair 23) are XO

When meiosis goes wrong

Occasionally meiosis goes wrong. For example, Down syndrome is usually the result of an error at meiosis when an egg or sperm cell gets an extra chromosome 21. So most people with Down syndrome have one too many chromosomes. Errors at meiosis occur more often in the egg cell as women get older, so the chances of a couple having a baby with Down syndrome rises from about one in 1400 in women under the age of 25, to one in a 100 by age 40.

RECESSIVE GENETIC DISORDERS

Theses disorder only appear when the offspring is homozygous (alleles the same) for a trait.
Both parents may appear normal but be heterozygous, but pass the recessive allele to their offspring.

EX. Sickle Cell anemia - homozygous recessive disorder in which red blood cells are sickle shaped instead of disc shaped. Sickle cells can't deliver enough oxygen to the cells in the body and do not move through the blood vessels easily.

Cystic Fibrosis is a homozygous recessive disorder in which thick mucus is produced in the lungs and digestive tract. Mucus in the lungs restricts oxygen intake. In the digestive system, enzymes can't reach food to break it down and properly absorb the nutrients required by the body.

Sex Determination

The X and Y chromosomes contain the genes that determine the gender (sex) of an individual. The sex of an individual is determined by the presence of the X and/or Y on the 23rd pair of chromosomes in humans.

XX = female XY = male

Just as with all chromosomes, mutations can occur or mistakes during meiosis, resulting in an incorrect combination of the X or Y chromosomes.

EX. Turner's syndrome, Klinefelter's syndrome, super female syndrome, etc.

Sex Linked Characteristics or Disorders

The X and Y chromosomes carry alleles for traits other than the traits determining gender of an individual. EX. red-green color blindness, hemophilia, coat color in cats

Hemophilia is a disorder in which blood does not clot properly. Even a small scrape can be life threatening.

An allele inherited on a sex chromosome is a sex-linked gene.

*refer to the handout on how to do Punnett Squares for sex linked traits

PUNNETT SQUARES FOR SEX-LINKED TRAITS

All sex-linked traits that we will work with in this class will be carried on the X chromosome, NONE are on the Y chromosome. As soon as you read the words "this is a sex linked trait" in the problem, put X X across the top of the Punnett Square for mom and X Y down the left side for the dad.

	X	X
X	X X	X X
Y	X Y	X Y

The phenotype in a sex linked cross must include the gender of the individual. EX. carrier

A heterozygous individual for a sex-linked trait is called a CARRIER. Only females can be carriers for sex-linked traits in this class.

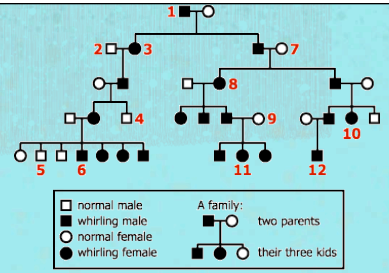
Remember heterozygous means that they have different alleles.

H = normal blood clotting factors

h = hemophiliac (missing clotting factors) blood doesn't clot

	X^H	X^h ♀ carrier
X^H	$X^H X^H$ ♀ normal	$X^H X^h$ ♀ carrier
Y	$X^H Y$ ♂ normal	$X^h Y$ ♂ hemophiliac

♂ normal



A pedigree is a tool for tracing a trait in a family. Males are represented by a square and females by a circle.

Pedigrees can help geneticists determine if a trait is recessive, dominant, sex-linked, or has some other pattern of inheritance. Knowing how a trait is inherited and help predict the probability that future offspring will inherit that trait.

Pedigrees are also important in breeding animals or plants. Organisms may be bred for desired traits or to increase yield and nutritional value.

Pedigrees show the occurrence of a trait in a family.

Why is Genetics important?

The principles of heredity are being used to change the world. Through genetic engineering scientists are experimenting with biological and chemical methods to change the arrangement of DNA that makes up a gene.

REMEMBER: Chromosomes are found in the nucleus of a cell, are made up of DNA, genes are sections of DNA on a chromosome that code for a specific trait of cell activity.

Genetic engineering is used to produce large volumes of medicine (EX. insulin), find ways to improve crop production and quality (plants that are resistant to disease), and change how cells perform their normal functions.

Recombinant DNA is one method of genetic engineering - this is used to help manufacture large quantities of medicine. A useful segment of DNA from one organism is inserted into a bacterium.

Gene Therapy

another method of genetic engineering. A normal allele is placed in a virus, the virus then delivers the normal allele when it infects its target cell. The normal allele replaces the defective one. This may be helpful in controlling genetic disorders such as cystic fibrosis and even some forms of cancer.

Genetically engineered plants

improvement upon plants and their desired characteristics has been going on for years through selective breeding. Now scientists look for desired traits in one plant and insert the genes for those traits into another plant.

Now take advantage of the fact that I've given you these notes over chapter 11 and

STUDY this material