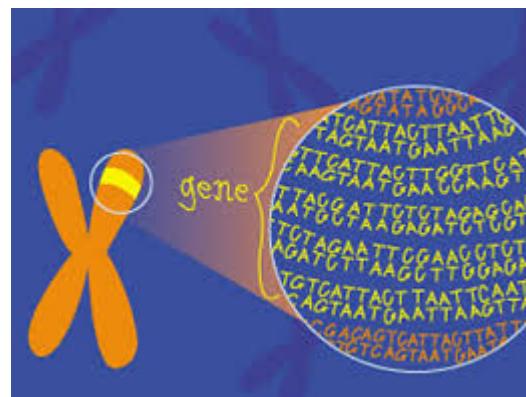


Cedar Ridge High School

Biology 2018-19



Genetics

Name: _____

Teacher: _____

Class Period: _____

Units 08 Genetics & Modern Genetics

6E: Identify and illustrate changes in DNA and evaluate the significance of these changes

- I can define mutation
- I can define point mutations and frameshift mutations
- I can define substitution, insertion, and deletion
- I can identify substitutions, insertions, and deletions
- I can differentiate between gene mutations and chromosomal mutations
- I can define and identify deletion, duplication, inversion, and translocation mutations
- I can discuss advantages and disadvantages to mutations
- I can discuss the positive and negative effects of mutations on organisms and populations
- I can explain the significance of mutations on living things

6F: predict possible outcomes of various genetic combinations such as monohybrid crosses, dihybrid crosses and non-Mendelian inheritance

- I can define the following terms: allele, gene, chromosome, genotype, and phenotype.
- I can distinguish between alleles, genes, and chromosomes.
- I can explain the relationships among alleles, genes, chromosomes, genotypes, and phenotypes.
- I can infer phenotypes based upon a particular genotype.
- I can create and interpret Punnett Squares.
- I can use the rules of probability to predict the genotypic and phenotypic outcomes in monohybrid crosses.
- I can define, explain the effect of, and solve genetic word problems involving the following types of inheritance: complete dominance, incomplete dominance, codominance, sex linkage, multiple alleles, and dihybrid crosses.
- I can make predictions about genotypes and phenotypes using probability.

6G: recognize the significance of meiosis to sexual reproduction

- I can explain what homologous chromosomes are and describe how they are similar and how they are different.
- I can distinguish between haploid and diploid cells.
- I can explain how meiosis increases genetic variation through crossing over and assortment of chromosomes.
- I can explain the role of meiosis in gamete formation.
- I can explain how the failure of chromosomes to separate during meiosis (*nondisjunction*) leads to changes in total chromosome number which can be displayed in a karyotype.
- I can describe the process of meiosis and explain its role in inheritance

TEKS/SE	Unit: Genetics & Modern Genetics
6E Genetics	<p>Fundamental Questions</p> <ul style="list-style-type: none"> • How do changes in DNA affect the production of amino acids? • Why is it important that gene expression is regulated? • How is gene expression related to mutations? Cancer development?
6FG Genetic Outcomes	<p>Fundamental Questions</p> <ul style="list-style-type: none"> • How are genetic combinations predicted? • Why is meiosis significant to sexual reproduction? • What techniques are used to study genomes of organisms? • Define crossing-over and why it is important.

Academic Vocabulary:

allele*	inherited trait
anticodon*	law of independent assortment
base sequence*	law of segregation
chromatid*	meiosis
chromosomal mutation	Mendel's laws of inheritance
chromosome*	monohybrid cross
codominance	non-disjunction
crossing over*	non-Mendelian inheritance
dihybrid cross*	offspring*
diploid*	phenotype*
dominance*	principle of dominance
dominant trait	Punnett square*
gamete*	recessive (trait)*
gene mutation	sex cell
gene*	transcription
genetic variety*	translation*
genotype*	variation*
haploid*	
heterozygous*	
homozygous*	
incomplete dominance	

**used on STAAR*

Part B — Reduce.

In Part B, write key words or questions from your notes

Here is an example of key words or questions.

Date Oct. 12Page Number 1**Part A — Write Notes.**

In part A, write your notes during the lecture or while you read.

Here is an example of classroom or reading notes.

Metric System**A. Beginning of Metric System**

Where was the metric system started?

1. Started in France in late 18th century.

Where did the word "meter" come from?

2. Group of scientists decided on a length and called it "meter."

3. Meter comes from the Greek word Metron— meaning "a measure."

B. Adapting the Metric System

When was the metric system first adopted?

1. Adopted in France in 1793.

Who changed France back to the old system of measurement?

2. Many people were against it.

3. Napoleon changed back to the old system of measurement in 1812.

4. The metric system was adopted again in 1840 and has been used ever since.

C. Units of Measurement

1. The metric system has 7 base units of measurement.

a. The 7 base units are

1) meter

2) kilogram

3) second

4) ampere

5) kelvin

6) mole

7) candela

Part C—Summarize. In Part C, summarize the notes that you wrote in Part A.

Here is an example of a summary.

Scientists in France "discovered" the meter. After many years, the metric system was adopted in France in 1840. Since the meter, they have added 6 more units of measurement: kilogram, second, ampere, kelvin, mole, and candela.

Name: _____ Date: _____ / _____ / _____

SUMMARY GRAPHIC ORGANIZER

Title: _____

Main Idea

Circle the 3 most important words in the Main Idea, and then write them here:

_____ _____ _____

Three Important Details

1) _____

2) _____

3) _____

Summary of the Passage in ONE Sentence

6.1 Chromosomes and Meiosis

KEY CONCEPT Gametes have half the number of chromosomes that body cells have.

You have body cells and gametes.

All of the different cells in your body can be divided into two groups: somatic cells and germ cells.

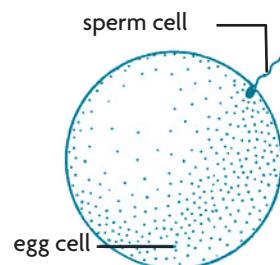
- **Germ cells** are the cells in your reproductive organs—the ovaries or testes—that develop into eggs or sperm.
- **Somatic cells** (soh-MAT-ihk), or body cells, are all the other cells in your body.

Somatic cells make up most of your tissues and organs. The DNA in your somatic cells will not be passed on to your children. Only the DNA in the egg or sperm cells gets passed on to offspring. Egg cells and sperm cells are called **gametes**.

Each species has a characteristic number of chromosomes per cell. For example:

- **Humans** have 23 pairs of chromosomes. In other words, there are $23 \times 2 = 46$ chromosomes in all body cells.
- **Fruit flies** have 4 pairs of chromosomes, or 8 chromosomes per cell.
- **Yeast** have 16 pairs of chromosomes, or 32 chromosomes per cell.

The organism currently known to have the most chromosomes is a fern. It has more than 1200 chromosomes. Chromosome number is not related to the size or complexity of an organism.



Egg cells and sperm cells are called gametes.



Do gametes come from germ cells or somatic cells?

Your cells have autosomes and sex chromosomes.

Suppose you had 23 pairs of gloves. You would have a total of $23 \times 2 = 46$ gloves. You could divide them into two sets: 23 right-hand and 23 left-hand gloves. Similarly, your body cells have 23 pairs of chromosomes, for a total of 46. These can be divided into two sets: 23 from your mother and 23 from your father. Just as you use both gloves if it is cold outside, your cells use both sets of chromosomes to function properly.

Each pair of chromosomes is called a homologous pair. Here, *homologous* means “having the same structure.” **Homologous chromosomes** are two chromosomes—one from the mother and one from the father—that are the same size and have copies of the same genes.

Although each chromosome in a homologous pair has copies of the same genes, the two copies may differ. For example, each chromosome in a pair might have a gene that influences eye color. But the gene on one chromosome of the pair may lead to brown eyes and the gene on the other chromosome may lead to green eyes.

One of your 23 pairs of chromosomes is your pair of **sex chromosomes**. These chromosomes control the sex of an organism. Humans, and all mammals, have two different sex chromosomes called X and Y.

- Females have two X chromosomes.
- Males have one X chromosome and one Y chromosome.

The rest of your chromosomes—the other 22 pairs—are called **autosomes**. These chromosomes contain genes for all of the rest of an organism's life functions.



If a person's pair of sex chromosomes is XY, is the person male or female?

Body cells are diploid; gametes are haploid.

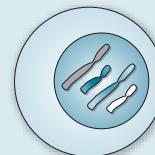
Sexual reproduction involves two gametes—an egg and a sperm—joining together. **Fertilization** happens when the egg and sperm actually combine. The nucleus of the egg combines with the nucleus of the sperm to form one nucleus. This new nucleus must have the correct number of chromosomes—46 for humans. Therefore, the egg and sperm each must each have half that number of chromosomes—23 for humans.

Diploid and Haploid Cells

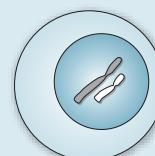
Gametes—eggs and sperm—are **haploid** (HAP-LOYD) cells. Haploid cells have one copy of each chromosome—again, 23 for humans. A sperm and egg join together to form a **diploid** (DIHP-LOYD) cell—for a total of 46 chromosomes for humans. Body cells are all diploid. Only gametes are haploid.

VISUAL VOCAB

Diploid cells have two copies of each chromosome: one copy from the mother and one from the father.



Body cells
are diploid ($2n$).



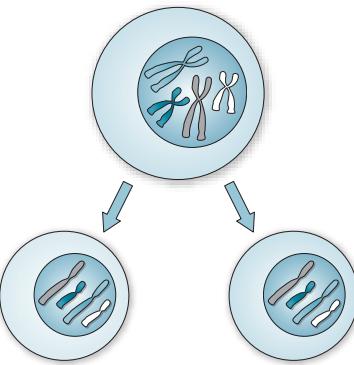
Gametes (sex cells)
are haploid (n).

Haploid cells have only one copy of each chromosome.

Meiosis

The germ cells in your reproductive organs form gametes through a process called meiosis. **Meiosis** (my-OH-sihs) is a process that divides a diploid cell into a haploid cell. In Chapter 5 you learned about mitosis, another process that divides a cell. The figure on the next page shows some of the differences between mitosis and meiosis.

COMPARING MITOSIS AND MEIOSIS

MITOSIS	MEIOSIS
	Produces genetically identical cells
Results in diploid cells	Produces genetically unique cells
Takes place throughout an organism's lifetime	Results in haploid cells
Involved in asexual reproduction	Takes place only at certain times in an organism's life cycle
	Involved in sexual reproduction

Remember that mitosis results in two identical diploid cells. Mitosis is used for development, growth, and repair. In contrast, meiosis results in four haploid cells that are unique. Meiosis happens only in germ cells to make gametes. Meiosis will be presented in detail in the next section.



What is the difference between the cells that result from mitosis and the cells that result from meiosis?

6.1 Vocabulary Check

somatic cell	sexual reproduction
gamete	fertilization
homologous chromosome	haploid
sex chromosome	diploid
autosome	meiosis

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.



- when the nucleus of an egg joins the nucleus of a sperm _____
- a body cell _____
- an egg or sperm cell _____
- any chromosome except a sex chromosome _____

6.1 The Big Picture

- If a diploid cell with 8 chromosomes goes through meiosis, how many chromosomes will the resulting haploid cells have? _____
- Circle the sex of a person with the sex chromosomes XX: male / female

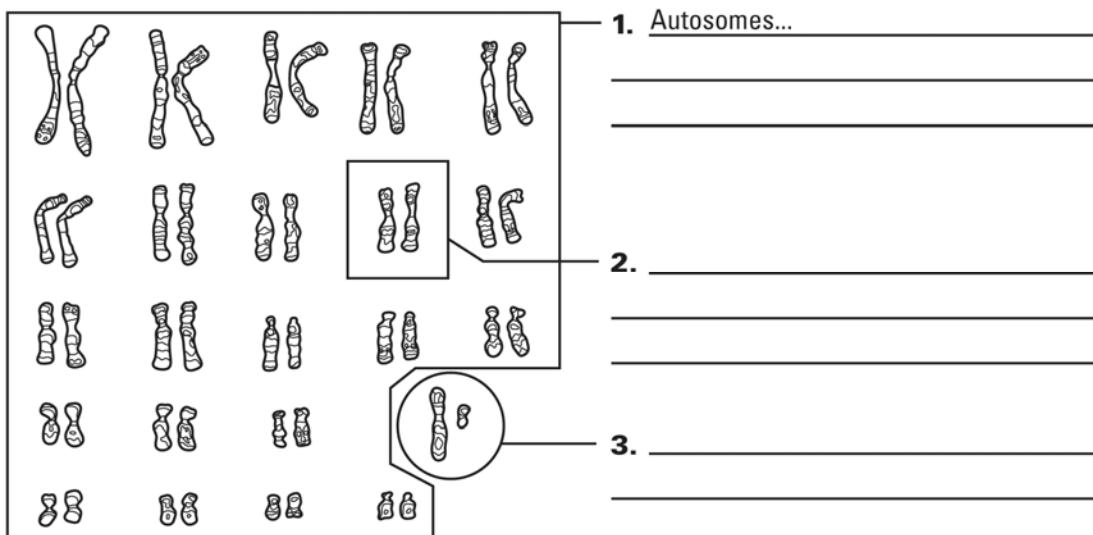
Name: _____ Class: _____ Date: _____

Section 1: Chromosomes and Meiosis

PowerNotes

Somatic cells:	Gametes:
•	•
•	•

Identify the items in the karyotype and explain their characteristics.



Diploid cell:

Haploid cell:

Mitosis	Meiosis
•	•
•	•
•	•
•	•

6.2

Process of Meiosis

KEY CONCEPT During meiosis, diploid cells undergo two cell divisions that result in haploid cells.

Cells go through two rounds of division in meiosis.

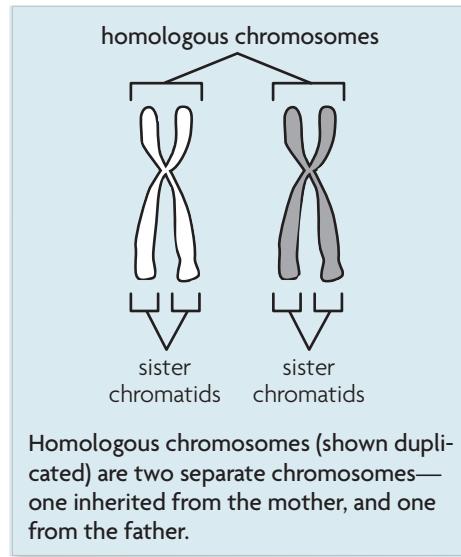
Meiosis begins with a diploid cell that already has duplicated chromosomes. There are two rounds of cell division—meiosis I and meiosis II. The phases of meiosis are similar to the phases of mitosis. To keep the two processes separate in your mind, focus on the big picture. Mitosis results in identical diploid cells, and meiosis results in unique haploid cells.

Homologous Chromosomes and Sister Chromatids

Recall that homologous chromosomes are two separate chromosomes: one from your mother and one from your father. Homologous chromosomes carry the same genes in the same order. However, the copies of the genes may differ. Homologous chromosomes are not copies of each other. In contrast, recall that a duplicated chromosome is made of two sister chromatids, attached at the centromere. Sister chromatids are identical copies of each other.

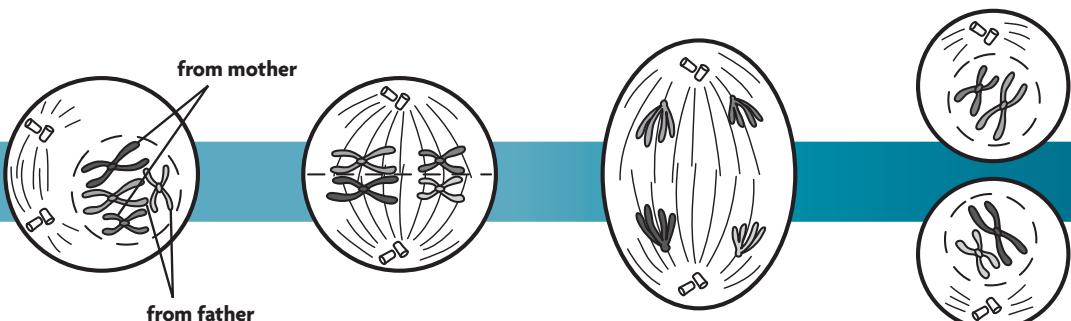
The Process of Meiosis

Before meiosis begins, DNA has already been copied. Homologous chromosomes are separated in the first half of meiosis—meiosis I. This results in two haploid cells with duplicated chromosomes. These cells are haploid because they each have only one of every pair of homologous chromosomes. Sister chromatids are separated in the second half of meiosis—meiosis II. This results in four haploid cells with unduplicated chromosomes. Like mitosis, scientists describe this process in phases. Follow the process of meiosis illustrated on the next page. The figure is simplified, showing only four chromosomes.



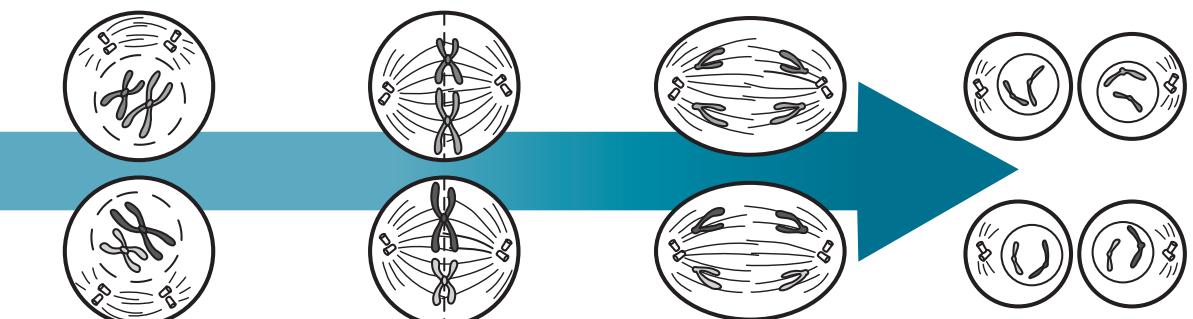
MEIOSIS

Meiosis I separates homologous chromosomes.



- 1 **Prophase I** The nuclear membrane breaks down. The duplicated chromosomes condense and homologous chromosomes begin to pair up. Notice that there are two pairs of duplicated homologous chromosomes.
- 2 **Metaphase I** The chromosomes line up along the middle of the cell.
- 3 **Anaphase I** The paired homologous chromosomes separate. Sister chromatids remain attached.
- 4 **Telophase I** Cytokinesis separates the cells. Each cell contains only one of each pair of chromosomes—not both. In other words, the cells are now haploid. The chromosomes are still duplicated.

Meiosis II separates sister chromatids. The overall process produces haploid cells.



- 5 **Prophase II** The nuclear membrane breaks down and the cells prepare to divide.
- 6 **Metaphase II** The chromosomes line up along the middle of the cell.
- 7 **Anaphase II** The sister chromatids are separated and move to opposite sides of the cell.
- 8 **Telophase II** The nuclear membranes form again. The result of meiosis is four haploid cells with a combination of chromosomes from both the mother and father.

Now that you've seen how meiosis works, let's review two key differences between the processes of meiosis and mitosis.

- Meiosis has two cell divisions. Mitosis has only one cell division.
- Meiosis results in haploid cells. Mitosis results in diploid cells.



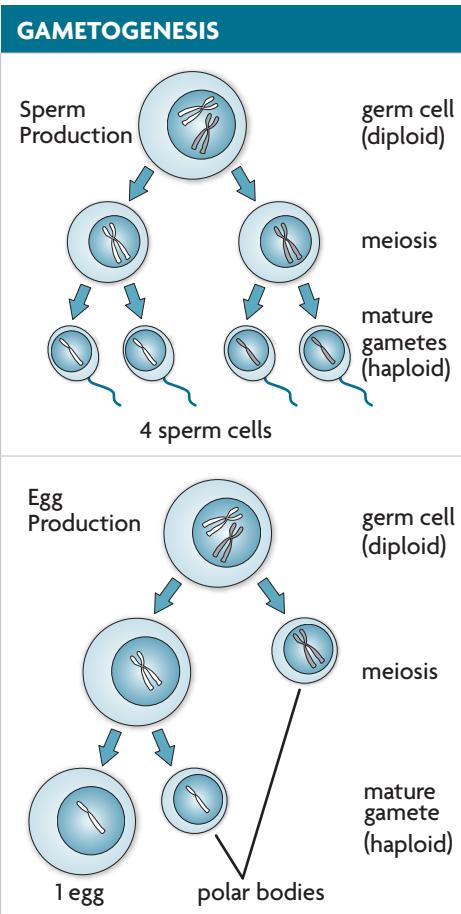
On the diagram above, circle the part in the process of meiosis when the cells first become haploid.

Haploid cells develop into mature gametes.

Gametogenesis (guh-MEE-tuh-JEHN-ih-sihs) is the production of gametes—eggs or sperm. Gametogenesis includes both meiosis and other changes that the haploid cells must go through. The **sperm** cell, the male gamete, is much smaller than the **egg**, the female gamete. After meiosis, a cell that develops into a sperm will form a compact shape with a long tail, or flagellum, that the cell uses to move. For egg production, only one of the cells from meiosis becomes an egg. It receives most of the cytoplasm and organelles. The other cells produced by meiosis become **polar bodies**, smaller cells that contain little more than DNA, and are eventually broken down.



How do mature gametes differ from the immature haploid cells?



6.2 Vocabulary Check

gametogenesis egg
sperm polar body

Choose the correct term from the list above to complete the sentences below.

1. Sperm and eggs are formed through the process of _____.
2. For egg formation, one of the cells resulting from meiosis becomes an egg and the others become _____.

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.



6.2 The Big Picture

3. What is the end result of meiosis? _____
4. What are two differences between meiosis and mitosis? _____

Name: _____ Class: _____ Date: _____

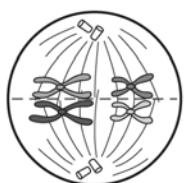
Section 2: Process of Meiosis

PowerNotes

Homologous chromosomes:

Sister chromatids:

Meiosis I



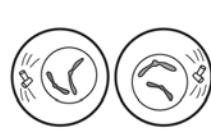
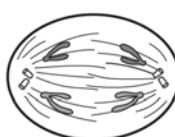
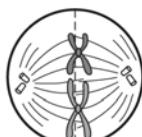
1.

2.

3.

4.

Meiosis II



5.

6.

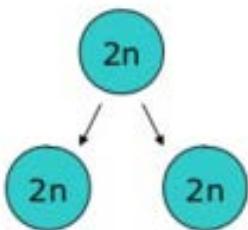
7.

8.

Meiosis Notes

Key Concept:

Somatic Cells - Body Cells

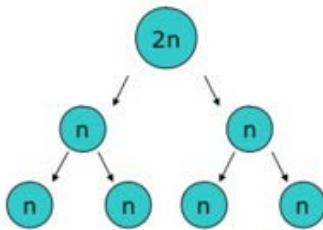


- Mitosis and cytokinesis make new body cells.
 - Body cells are _____ or $(2n)$ cells.
 - $n =$ number of chromosomes in a set

 - Body cells are also called _____ cells.
 - In humans, body cells or somatic cells have _____
_____ or _____ pairs of chromosomes.
 - One set of chromosomes comes from each parent.

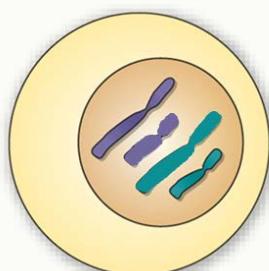
Sex Cells

- Come from _____.
 - Germ cells are located in the ovaries and testes.
 - Sex cells are also called _____.
 - Examples of gametes _____ and _____.
 - Gametes have DNA that can be passed to offspring.



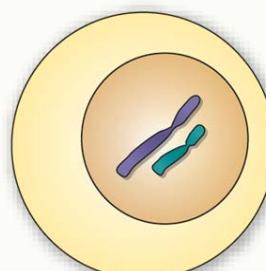
- Meiosis produces sex cells or gametes.
 - Gametes are _____ cells (n).
 - They only have one set of chromosomes.
 - In humans, gametes have _____ chromosomes.

Comparing Somatic Cells and Gametes



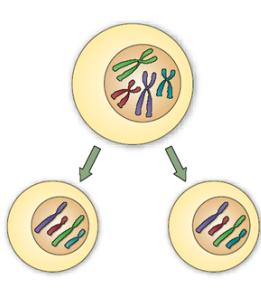
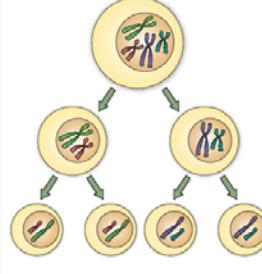
Body cells
are diploid ($2n$).

- Somatic cells or body cells have _____ copies of every chromosome.
 - One copy comes from each _____
 - Produced by mitosis.



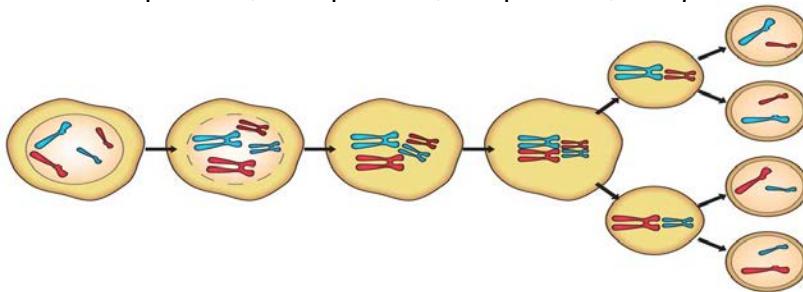
Gametes (sex cells) are haploid (n).

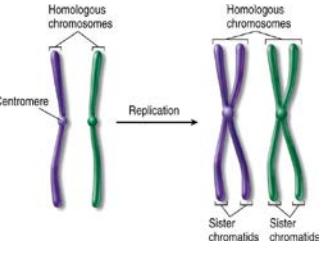
- Sex cells or _____ have one copy of every chromosome.
 - Produced by meiosis.

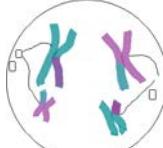
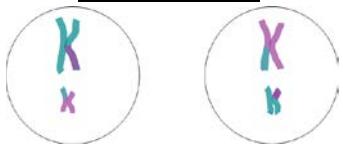
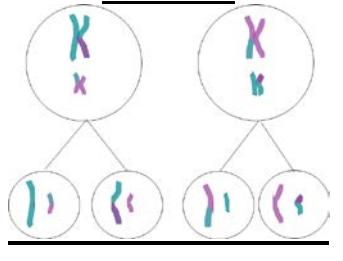
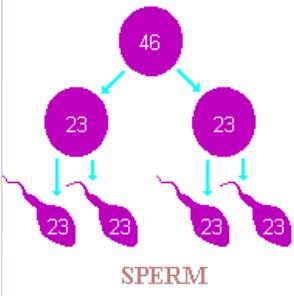
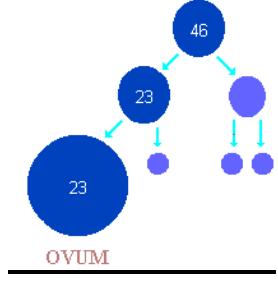
Mitosis	vs.	Meiosis								
<ul style="list-style-type: none"> • Produces _____ daughter cells • Daughter cells have two sets of each pair of chromosomes (_____). • Daughter cells are genetically _____ to each other and to the original cell. <div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 10px; margin-right: 20px;"> MITOSIS  </div> <table border="1" style="border-collapse: collapse; width: 100%;"> <tr> <td style="padding: 5px;">Produces genetically identical cells</td> </tr> <tr> <td style="padding: 5px;">Results in diploid cells</td> </tr> <tr> <td style="padding: 5px;">Takes place throughout an organism's lifetime</td> </tr> <tr> <td style="padding: 5px;">Involved in asexual reproduction</td> </tr> </table> </div>	Produces genetically identical cells	Results in diploid cells	Takes place throughout an organism's lifetime	Involved in asexual reproduction		<ul style="list-style-type: none"> • Produces _____ daughter cells • Daughter cells have one set of each pair of chromosomes (_____). • Daughter cells are genetically _____ from each other and from the original cell. <div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 10px; margin-right: 20px;"> MEIOSIS  </div> <table border="1" style="border-collapse: collapse; width: 100%;"> <tr> <td style="padding: 5px;">Produces genetically unique cells</td> </tr> <tr> <td style="padding: 5px;">Results in haploid cells</td> </tr> <tr> <td style="padding: 5px;">Takes place only at certain times in an organism's life cycle</td> </tr> <tr> <td style="padding: 5px;">Involved in sexual reproduction</td> </tr> </table> </div>	Produces genetically unique cells	Results in haploid cells	Takes place only at certain times in an organism's life cycle	Involved in sexual reproduction
Produces genetically identical cells										
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Involved in asexual reproduction										
Produces genetically unique cells										
Results in haploid cells										
Takes place only at certain times in an organism's life cycle										
Involved in sexual reproduction										

How Does Meiosis Work?

- Meiosis involves two cellular divisions instead of just one.
- Meiosis I - Prophase I, Metaphase I, Anaphase I, Telophase I
- _____ - Prophase II, Metaphase II, Anaphase II, Telophase II



G1 	<ul style="list-style-type: none"> • Initial stages are very similar to mitosis. • The germ cell is diploid ($2n$). • G1 - The cell _____ and makes organelles.
S, G2 	<ul style="list-style-type: none"> • S- the cell replicates its DNA. This is the only time DNA will be replicated. • G2 - the cell prepares for _____.
	<p style="text-align: center;">Homologous Chromosomes</p> <ul style="list-style-type: none"> • Homologous chromosomes are two chromosomes that contain the same _____. • One chromosome comes from each parent.

<p><u>Prophase I</u></p> 	<p>Prophase I = Crossing Over - Causes Genetic Variation</p> <ul style="list-style-type: none"> Homologous chromosome pairs come close together and <u>exchange</u> part of their chromosomes - called crossing over. Results in new combinations of genes or recombination.
<p><u>Metaphase I</u></p> 	<p>Metaphase I = Independent Assortment - Causes Genetic Variation</p> <ul style="list-style-type: none"> Homologous pairs line up next to each other in the middle of the cell. It is <u>random</u> what side each chromosome will end up on. This is called random or <u>independent assortment</u>.
<p><u>Anaphase I</u></p> 	<p>Anaphase I</p> <ul style="list-style-type: none"> Homologous chromosome pairs are pulled <u>apart</u> towards opposite sides of the cell.
<p><u>Telophase I / Cytokinesis I</u></p> 	<p>Telophase I/Cytokinesis I</p> <ul style="list-style-type: none"> Nuclear membrane reforms, chromosomes become chromatin, cell membrane splits. End of Meiosis I - Each cell is now a <u>haploid</u> cell (n) because it only contains one set of chromosomes.
<p><u>Meiosis II</u></p> 	<ul style="list-style-type: none"> Without going through G1, S, and G2 again, the two haploid daughter cells go through a second division. PMAT II Anaphase II: <u>chromosomes</u> are pulled apart. End of Meiosis II: Each of the four daughter cells are <u>haploid</u> (n) and contain half of the number of chromosomes as the original cell. They are all genetically different from each other and from the original cell.
<p>Gametogenesis - Egg and Sperm Production</p>	
 <p>1 germ cell = _____ sperm cells</p>	 <p>1 germ cell = _____ egg cell and 3 polar bodies that will be broken down</p>

How does meiosis cause genetic variation?

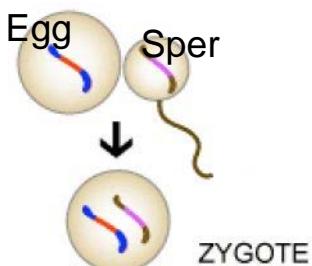
- Crossing Over** - Occurs during _____ and provides almost infinite combinations of genes on chromosomes.
- Independent Assortment** of chromosomes occurs during _____. It provides over 8 billion combinations of chromosomes.

DOG VARIATIONS



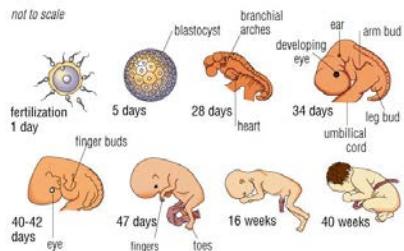
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Sexual Reproduction Leads to Genetic Variation

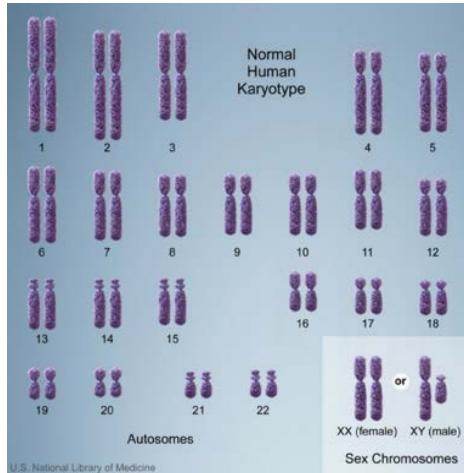


When _____ between the sperm (n) and the egg (n) occurs, the new cell is now diploid (2n)

A _____ is the first cell of a brand new organism!



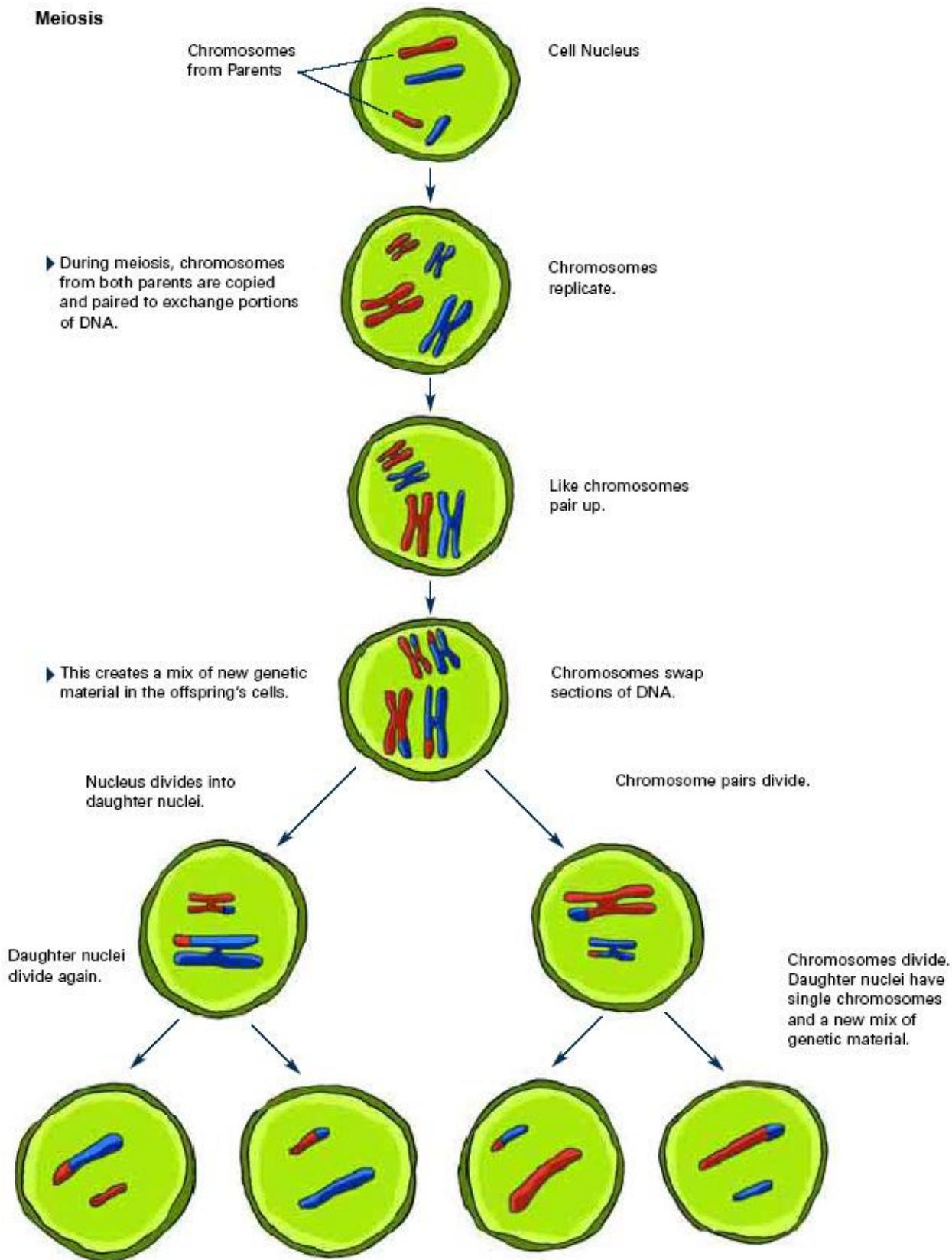
- The zygote develops into a brand new _____.



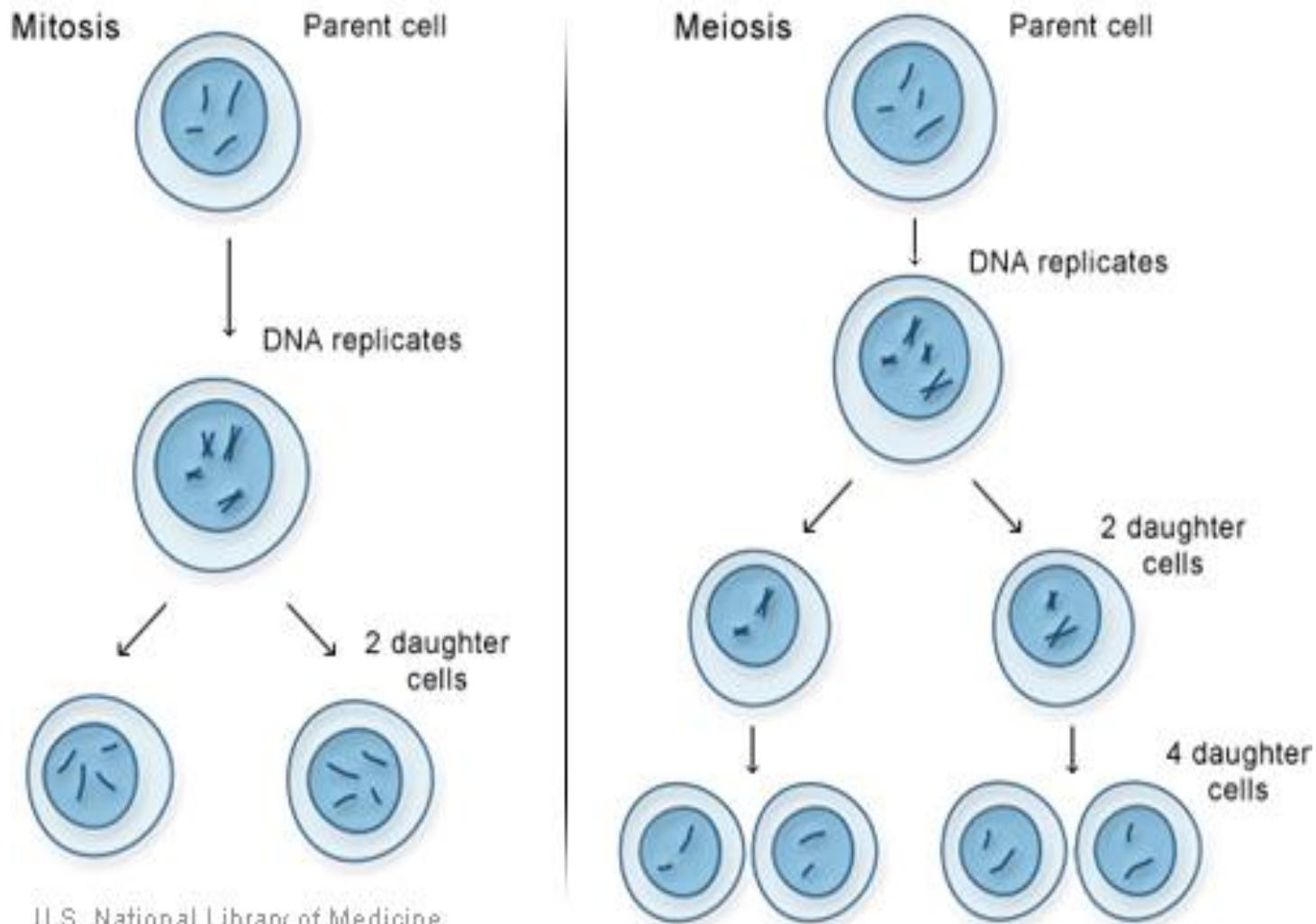
Each cell of the new organism is diploid with 2 sets of chromosomes.

- _____ Chromosomes that contain genes for characteristics not related to the sex of the organism. Pairs 1-22.
- _____ Chromosomes that determine the sex of the organism.
- XX - _____
- XY - Male

MEIOSIS



COMPARISON OF MITOSIS AND MEIOSIS



U.S. National Library of Medicine

Genetics: My Parents Wrecked My Favorite Genes

Name: _____

Have you ever wondered who you look more like - your mom or your dad? Why don't you look like your pet hamster? It's all because of **genetics**, the study of heredity. **Heredity** is the passing of physical characteristics from parents to offspring. Your **DNA**, which contains your genes, came from your mom and dad, not from your pet hamster. That's why you probably look like a mixture of your parents. **Genes** control the traits you exhibit like your hair color, eye color, the ability to roll your tongue, and maybe even your sweaty feet!

Every cell in your body contains the DNA you inherited from your parents. All of these traits are controlled by the cell's nucleus. The **nucleus** holds your DNA which has the instructions for making specific proteins. Those proteins are made using the **ribosomes** located outside of the nucleus floating in the cytoplasm or attached to the rough endoplasmic reticulum. And because **proteins** are the building blocks of cells, tissues, and organs, they also control your **characteristics** - what you look like, your abilities, and sometimes even your behaviors.

When we try to better understand how we get **traits** (the different forms of a characteristic) from our parents, we use letters called **alleles** to represent the different forms of a gene. For example, if we're talking about having dimples, we might use a capital "D" for dimples and a lowercase "d" for no dimples. The capital letter represents the **dominant** trait, the one that overshadows all others. The lower case letter represents the **recessive** trait, the one that hides in the background. The result is three different combinations of these letters: DD, Dd, and dd. You get one gene from each parent – a letter from mom and a letter from dad - so that's why the alleles are paired with one another. The different combinations of alleles, or letters, make up the **genotype**. What those combinations mean or look like physically is called the **phenotype**. So, if you get a dominant "D" from dad and a dominant "D" from mom, then you will **homozygous** or **purebred** (two letters that are the same) and your phenotype would be having dimples, the dominant trait. If your dad gives you a recessive "d" and mom gives you a recessive "d" you would still be homozygous (purebred) and your phenotype would be no dimples, the recessive trait. However, if your dad gives a dominant "D" and mom gives you a recessive "d", then you would be **heterozygous** or **hybrid** (two letters that are different) and your phenotype would be having dimples because the "D" or dominant trait takes over and it overshadows or "dominates" the "d" recessive trait.

When a cell in your body (like a skin or muscle cell) reproduces and makes two cells, it's called **mitosis**. Mitosis results in cells that have 46 chromosomes in all – meaning you get 23 from mom and 23 from dad. However, when your parents' bodies make sex cells, sperm and egg, its called **meiosis**. Meiosis results in sperm and egg that have half the number of chromosomes, 23 total. So, when your parents made you, each one donated 23 chromosomes to the gene pool, giving you the 46 chromosomes of DNA that make you, uniquely you!

Genetics:

Name: _____

My Parents Wrecked My Favorite Genes

Vocabulary that Explains Who's to Blame!

Use the reading to match the vocabulary with the appropriate definition

1. _____ - makes proteins using directions from DNA.
2. _____ - the different forms of a characteristic (dimples: present or absent)
3. _____ - the trait that hides in the background (lowercase letter). Can only be expressed in homozygous form (Ex: dd).
4. _____ - the passing of physical characteristics from parents to offspring
5. _____ - the scientific study of heredity
6. _____ - cell reproduction- when one body cell becomes two
7. _____ - two alleles/letters for one trait that are the same (Ex: DD or dd)
8. _____ - combination of alleles (letters): DD, Dd, dd
9. _____ - the factor that controls a trait you exhibit
10. _____ - contains DNA and controls cell activities.
11. _____ - the building blocks of cells that control your specific characteristics.
12. _____ - the letters that represent the different forms of a gene (dimples: D= present; d= absent)
13. _____ - the trait that overshadows and is expressed (capital letter)
14. _____ - the physical appearance of a trait (Ex: dimples, no dimples)
15. _____ - two alleles/letters for one trait that are different (Ex: Dd)
16. _____ - produces four sex cells, sperm or egg that are used to pass a parent's traits to offspring.
17. _____ - contains your genes.

For the examples written below, provide the vocabulary term that represents each

18. This trait would be represented by a "B" or "D" or "Z": _____
19. This trait would be represented by a "b" or "d" or "z": _____
20. BB or bb; DD or dd; ZZ or zz would represent a _____ genotype.
21. Bb, Dd, and Zz would represent a _____ genotype.

Free Response:

22. Relate what you've learned about the cell to how we inherit traits from our parents.

Include and underline the following terms in your explanation: NUCLEUS, PROTEINS, DNA, RIBOSOMES, CHARACTERISTICS, GENES

Genetics:

Name: _____

My Parents Wrecked My Favorite Genes

Use the reading to answer the following questions

1. Relate what you've learned about the cell to how we inherit traits from our parents.

Include and underline the following terms in your explanation: NUCLEUS, PROTEINS, DNA, RIBOSOMES, CHARACTERISTICS, GENES

For the examples written below, provide the vocabulary term that represents each

2. This trait would be represented by a "B" or "D" or "Z": _____
3. This trait would be represented by a "b" or "d" or "z": _____
4. BB or bb; DD or dd; ZZ or zz would represent a _____ genotype.
5. Bb, Dd, and Zz would represent a _____ genotype.
6. What's another name for a heterozygous genotype? _____
7. What's another name for a homozygous genotype? _____
8. Identify the following as a: homozygous dominant genotype, homozygous recessive genotype, heterozygous genotypes, or phenotype

Trait	Vocabulary term it represents
NN	
Nn	
Brown fur	
nn	
Freckles	
Pp	
RR	
tt	
Dimples	

Write an example of the following terms using the letter "R" and "r" if "R" stands for being able to roll your tongue and "r" is not able to roll your tongue

9. Homozygous Dominant _____

10. Hybrid _____

11. Purebred Recessive _____

Genetics:

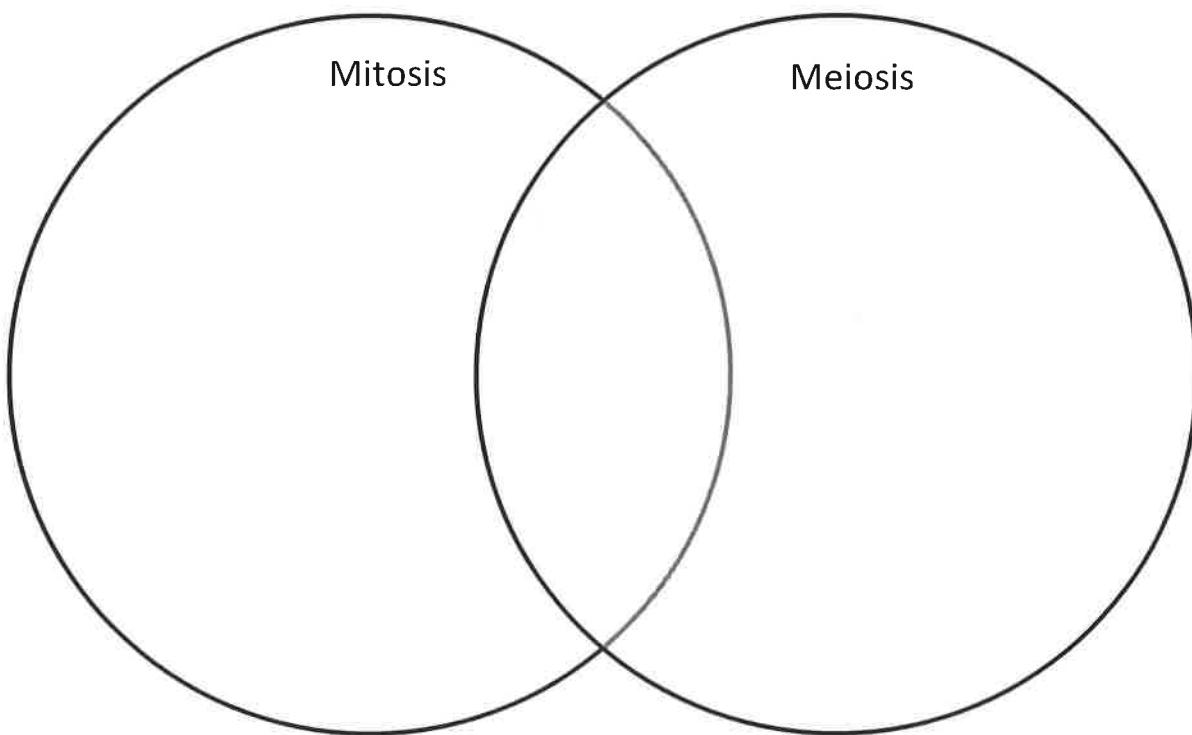
Name: _____

My Parents Wrecked My Favorite Genes

12. If a hamster has 22 chromosomes in its body cells, how many chromosomes would it have in its sex cells?

13. If a naked mole rat has 27 chromosomes in its sex cells, how many chromosomes would it have in its body cells?

14. Compare and contrast Mitosis and Meiosis using the diagram below:



15. So, why DON'T you look like your pet hamster?

16. How do you think the study of heredity may help the human race in the future?

Name _____ Block _____ Page # _____

Biology-Meiosis PNP

I. Vocabulary-Write the definition of each word and then draw a simple illustration to emphasize the meaning. Use your notes and the book (pages 162-170)

1.Somatic Cell	<i>illustration</i>	2.Gamete	<i>illustration</i>
3.Homologous Chromosome	<i>illustration</i>	4.Autosome	<i>illustration</i>
5.Sex Chromosomes	<i>illustration</i>	6.Diploid	<i>illustration</i>
7.Haploid	<i>illustration</i>	8.Meiosis	<i>illustration</i>
9.Gametogenesis	<i>illustration</i>	10.Sperm	<i>illustration</i>
11.Egg	<i>illustration</i>	12.Polar body	<i>illustration</i>

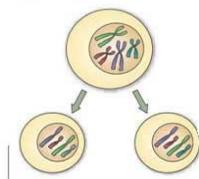
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II. Questions:

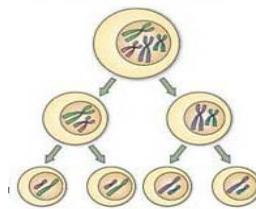
1. Which cell type makes up the brain? _____ (**Somatic or Germ cells**)
2. In what organs are gametes located in the body? _____
3. A typical human **body** cell has how many chromosomes? _____
4. A person with XY chromosomes is a _____ (**female or male**)
5. A sperm cell is a _____ cell. (**haploid or diploid**)
6. Is the zygote that results from fertilization a **haploid or diploid** cell?

Refer to the diagrams below and answer question 7.

A



B.



7. Which diagram (A or B) represents **Meiosis**? _____ **Mitosis**? _____

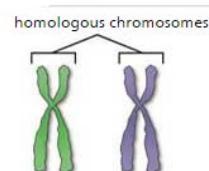
Which diagram makes diploid cells? _____

Which diagram makes haploid cells? _____

Which diagram makes genetically unique cells? _____

8. Two chromosomes that have the same genes, length, and overall appearance are called _____ chromosomes. (**somatic or homologous**)

9. Label the sister chromatids.



10. Which gamete contributes more to an embryo?

(sperm cell or egg cell) _____

11. During meiosis, homologous chromosomes separate during _____, while the sister chromatids separate during _____.

Choose from: prophase I, anaphase I, metaphase II, anaphase II

12. Why is it important that gametes are haploid cells?

13. Briefly explain how a sperm cell's structure is related to its function?

6.3

Mendel and Heredity

KEY CONCEPT Mendel's research showed that traits are inherited as discrete units.

Mendel laid the groundwork for genetics.

Traits are characteristics* that are inherited, such as eye color, leaf shape, or tail length. Scientists recognized that traits are hereditary, or passed from one generation to the next, long before they understood how traits are passed on. **Genetics** is the study of biological inheritance patterns and variation in organisms.

The study of genetics started in the 1800s with an Austrian monk named Gregor Mendel. He recognized that there are separate units of inheritance—what we now call genes—that come from each parent. Mendel studied inheritance in pea plants.



Highlight the sentence above that tells who Gregor Mendel was.

Mendel's data revealed patterns of inheritance.

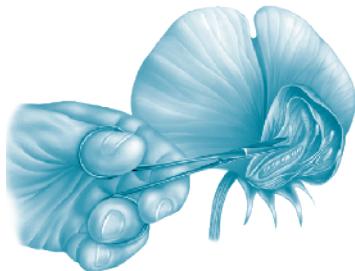
Three things about Mendel's experiments helped him develop his laws of inheritance.

1 He controlled the breeding of the pea plants he studied.

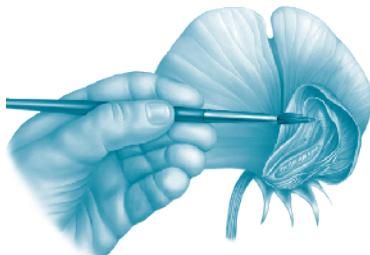
Pea flowers have both male and female parts. They usually self-pollinate. In other words, a plant mates with itself. As shown in the figure to the right, Mendel controlled the matings of his pea plants. He chose which plants to cross. In genetics, the mating of two organisms is called a **cross**.

2 He used “either-or” characteristics. Mendel studied seven different pea traits, including flower color and pea shape. All of the characteristics he studied had only two forms, so all plants either had one form or the other. For example, all of the flowers were purple or white. All of the peas were wrinkled or round.

MENDEL'S PROCESS



Mendel controlled the fertilization of his pea plants by removing the male parts, or stamens.



He then fertilized the female part, or pistil, with pollen from a different pea plant.

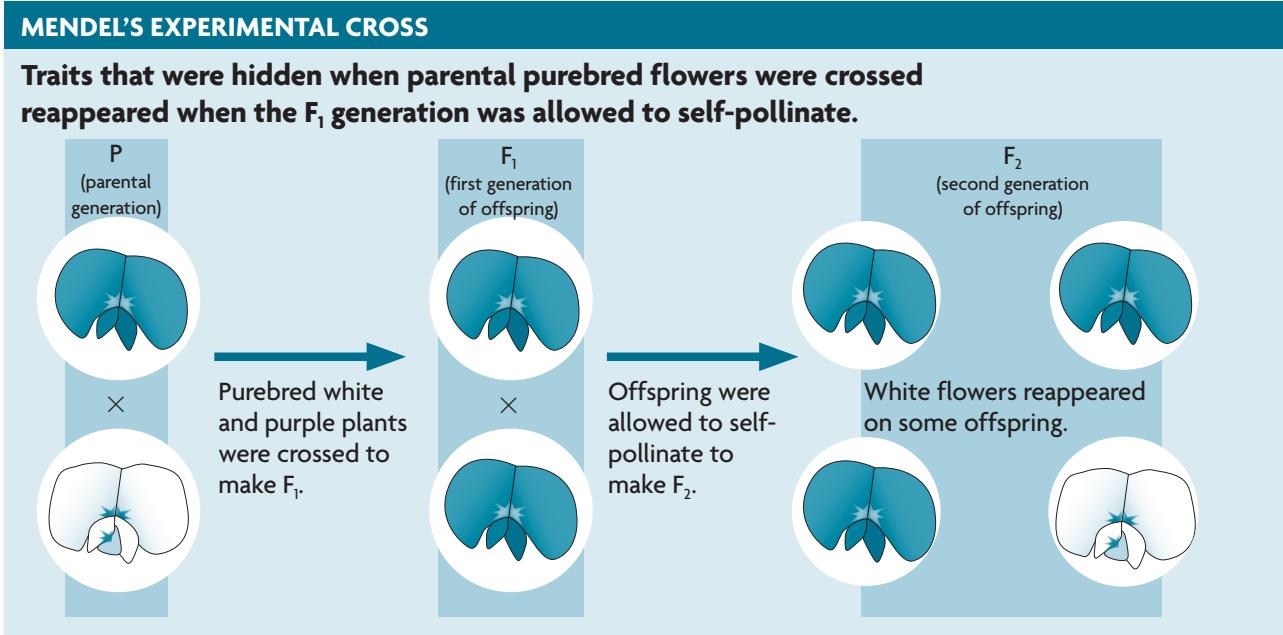
* ACADEMIC VOCABULARY

characteristic something that is recognizable, or that distinguishes someone or something

3 He used purebred plants. If a line of plants self-pollinates for long enough, the plants become genetically uniform, or **purebred**. The offspring of a purebred parent inherits all of the parent organism's characteristics—they are all the same as the parent. Because Mendel started with purebred plants, he knew that any variation in the offspring was a result of his crosses.

Results

Mendel found that when he crossed purebred plants, one of the forms of a trait was hidden in the offspring. But the form would reappear in the next generation.



Mendel studied many plants and made many crosses. He found similar patterns in all of his results. In the figure above, you can see that the white flowers disappeared in the first generation of offspring. In the second generation, however, he found that about one-fourth of the plants had the form of the trait that had disappeared in the first generation. The other three-fourths of the plants had purple flowers. In other words there was a 3:1 ratio of purple-flowered:white flowered plants in the second generation.

Conclusions

These observations helped Mendel form his first law, called the **law of segregation**. There are two main parts of this law.

- Organisms inherit two copies of each gene, one from each parent.
- Only one copy of a gene goes into an organism's gametes. The two copies of a gene separate—or segregate—during gamete formation.



Highlight the two parts of Mendel's law of segregation listed above.

6.3 Vocabulary Check

trait	purebred
genetics	law of segregation
cross	

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.



Choose the correct term from the list for each description.

1. the study of biological inheritance _____
2. the mating of two organisms _____
3. a characteristic that is inherited _____

6.3 The Big Picture

4. The law of segregation says that gametes receive only one chromosome from each homologous pair of chromosomes. Turn back to the image on page 97 that shows the process of meiosis. In which stage of meiosis do homologous chromosomes separate?

5. Give two examples of human traits that are not mentioned in the section above.

Name: _____ Class: _____ Date: _____

Section 3: Mendel and Heredity

PowerNotes

Mendel's Experiments

Three key choices:

-
-
-
-

Pea plant characteristics:

-
-
-
-
-
-

Cross:

- P
- F₁
- F₂

Results:

Conclusions:

-

Law of segregation:

-
-

6.4 Traits, Genes, and Alleles

KEY CONCEPT Genes encode proteins that produce a diverse range of traits.

The same gene can have many versions.

As you learned, the units of inheritance that Mendel studied are now called genes. You can think of a **gene** as a piece of DNA that stores instructions to make a certain protein. Each gene is located at a particular place on a chromosome called a locus. Just like a house has an address on a street, a gene has a locus on a chromosome.

Many things come in different forms. For example, bread can be wheat, white, or rye. Most genes have many forms, too. An **allele** (uh-LEEL) is any of the different forms of a gene. The gene for pea shape, for example, has two alleles—one for round peas and another for wrinkled peas.

Your cells, like the pea plant's cells, have two alleles for each gene—one on each chromosome of a homologous pair. The term **homozygous** (HOH-moh-ZY-guhs) means the two alleles of a gene are the same—for example, both alleles are for round peas. The term **heterozygous** (HEHT-uhr-uh-ZY-guhs) means the two alleles are different—for example, one allele is for wrinkled peas and one is for round peas.



Draw a circle around each of the alleles shown in the Visual Vocab to the right.

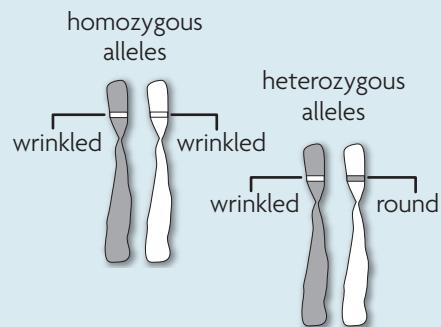
Genes influence the development of traits.

For Mendel's peas, if a plant was heterozygous for pea shape, the pea shape would be round. This is because the allele for round peas is **dominant**, or expressed when two different alleles are present. A **recessive** allele is expressed only when there are two copies of the recessive allele. A dominant allele is not better or stronger or more common; it is simply the allele that is expressed when there are two different alleles. Mendel studied traits that had just two alleles, one that was dominant and one that was recessive. Most traits involve much more complicated patterns of inheritance.

Alleles are represented with letters—capital letters for dominant alleles and lowercase letters for recessive alleles. For example, the dominant allele for round pea shape can be

VISUAL VOCAB

Homozygous alleles are identical to each other.

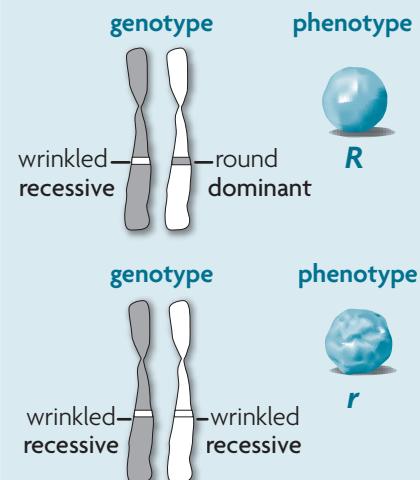


Heterozygous alleles are different from each other.

The drawing on p. 93 shows a homologous pair of duplicated chromosomes. Notice that here the chromosomes are drawn unduplicated. These are two homologous pairs of unduplicated chromosomes.

VISUAL VOCAB

A **dominant** allele is expressed when two different alleles are present.



A **recessive** allele is expressed only when two copies are present.

written as *R*, for round. The recessive allele, for wrinkled pea shape, can be represented with the same letter, but lowercase—*r*.

A **genotype** is the set of alleles an organism has for a trait. For example, a genotype could be homozygous dominant (*RR*), heterozygous (*Rr*), or homozygous recessive (*rr*). A **phenotype** is what the resulting trait looks like—for example, round or wrinkled. A **genome** is all of an organism's genetic material—all of the genes on all of the chromosomes.



What is the difference between a genotype and a phenotype?

6.4 Vocabulary Check

gene	recessive
allele	genotype
homozygous	phenotype
heterozygous	genome
dominant	

Mark It Up



Go back and highlight each sentence that has a vocabulary word in **bold**.

1. What is the difference between a gene and an allele? _____

2. What is the difference between a dominant allele and a recessive allele? _____

6.4 The Big Picture

3. Fill in the blanks in the chart below regarding pea shape.

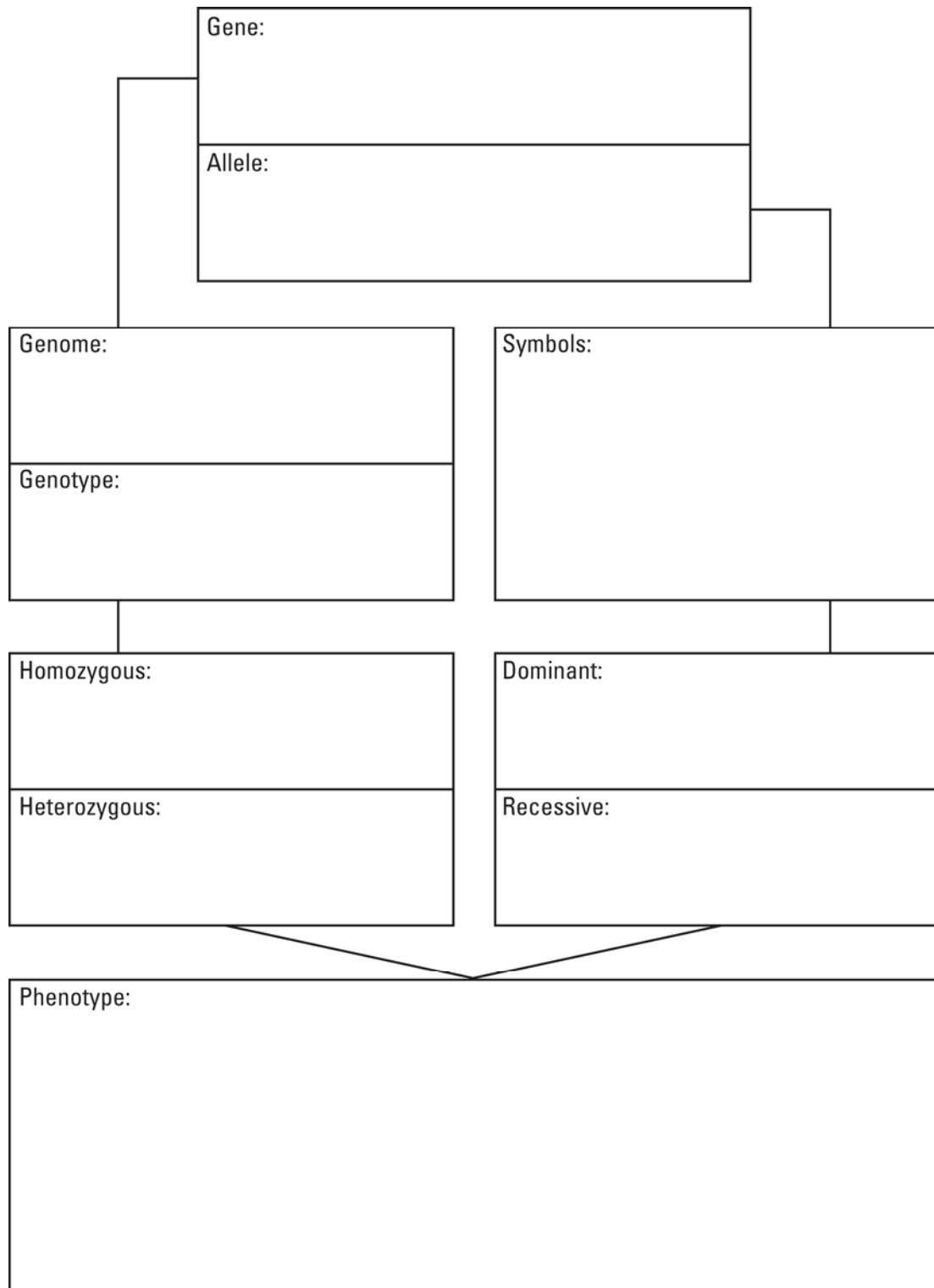
GENOTYPE	PHENOTYPE	HOMOZYGOUS OR HETEROZYGOUS
<i>RR</i>		homozygous dominant
<i>Rr</i>	round peas	
<i>rr</i>		homozygous recessive

4. Which of the alleles in the chart above is dominant? _____

Name: _____ Class: _____ Date: _____

Section 4: Traits, Genes, and Alleles

PowerNotes

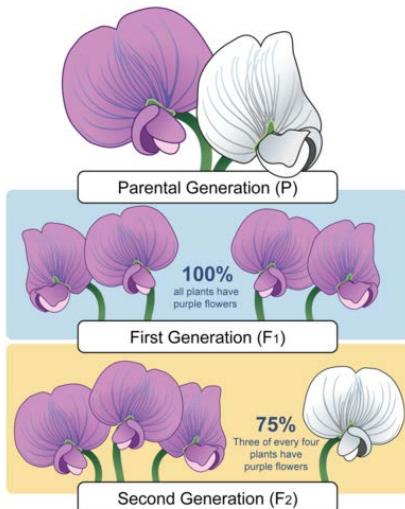


Notes - Mendelian Genetics**Key Concept****Who is Gregor Mendel?**

- Austrian monk who loved to garden. He was interested in how traits are passed down.
- Between 1856 and 1863 tested about 28,000 _____!
- Father of _____.

Gregor Mendel's Experiment

1. Mendel recorded all of his observations in an _____ journal.
2. Mendel used _____ pea plants.
3. Mendel took control of plant breeding using _____.
4. Mendel was also lucky because the traits he studied were either/or traits.

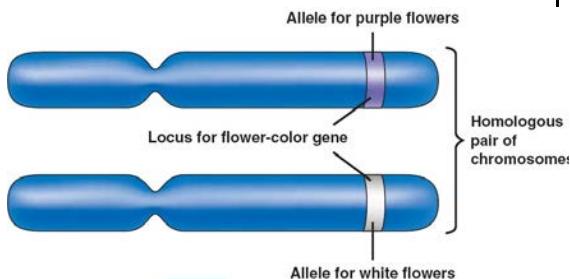


5. Mendel needed a way to keep track of all of the different generations of pea plants.

P Generation - the _____ generation in a breeding experiment.

F₁ Generation - the _____ generation of offspring in a breeding experiment.

F₂ Generation - the _____ generation of offspring in a breeding experiment (from breeding individual from F₁)

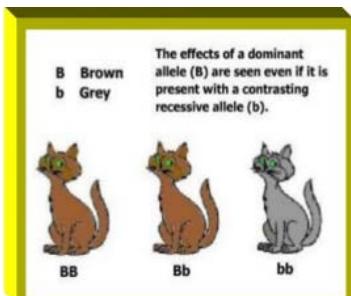
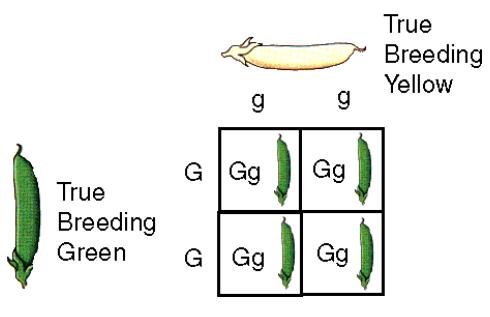
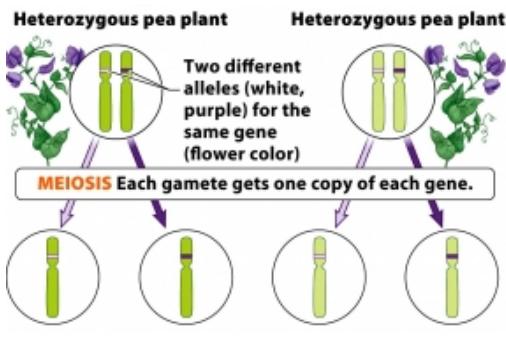


● **Traits** are inherited as discrete units called _____.

● For each gene we inherit two alleles, one from each parent.



Mendel's Conclusions and Laws

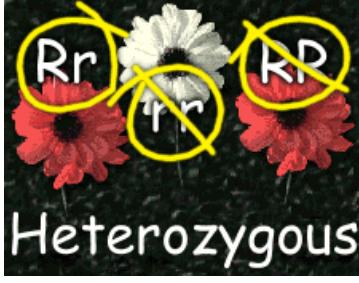
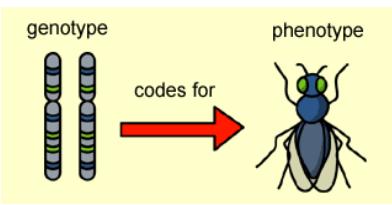
<p>Allele Dominance:</p> <ul style="list-style-type: none"> = is the dominant allele for flower colour = is the recessive allele for flower colour = Aa 	<ul style="list-style-type: none"> For the flower color gene, there are two possible alleles _____ or white. The purple allele (P) is dominant over the white recessive allele. 						
 <p>B Brown b Grey</p> <p>The effects of a dominant allele (B) are seen even if it is present with a contrasting recessive allele (b).</p> <p>BB Bb bb</p>	<ul style="list-style-type: none"> A _____ allele is expressed even if it is paired with a recessive allele. A recessive allele is only visible when paired with another recessive allele. 						
 <p>True Breeding Yellow</p> <p>True Breeding Green</p> <table border="1"> <tr> <td>G</td> <td>Gg</td> <td>Gg</td> </tr> <tr> <td>G</td> <td>Gg</td> <td>Gg</td> </tr> </table>	G	Gg	Gg	G	Gg	Gg	<ol style="list-style-type: none"> Mendel's Law of Dominance : In a cross of P generation plants that are pure bred for different traits, only _____ of the trait will appear in the F1 generation. All of the offspring will be heterozygous and express only the _____ trait.
G	Gg	Gg					
G	Gg	Gg					
 <p>Heterozygous pea plant</p> <p>Heterozygous pea plant</p> <p>Two different alleles (white, purple) for the same gene (flower color)</p> <p>MEIOSIS Each gamete gets one copy of each gene.</p>	<ol style="list-style-type: none"> Mendel's Law of Segregation Organisms inherit two copies of each gene, one from each parent. Organisms donate only one allele for each gene in their gametes. The two copies of each gene _____ or separate during gamete formation. 						

<p>Gene for flower color Allele for purple flowers (P) Allele for white flowers (p)</p> <p>Chromosome #1</p> <p>Gene for stem length Allele for tall stem (T) Allele for short stem (t)</p> <p>Chromosome #4</p>	<h3>3. Mendel's Law of Independent Assortment</h3> <ul style="list-style-type: none"> ● Alleles for different traits are located on different _____. ● During Metaphase I in Meiosis, homologous chromosome pairs line up independently of each other so different alleles are distributed to sex cells _____ of one another.
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Study of Heredity

What are traits?	A trait is a characteristic that is inherited. Traits are passed from parents to _____.
Genes determine our traits.	Genes - segments of _____ that code for proteins that produce traits.
The same gene can have many versions.	An allele is the form of the gene inherited from each parent. Homologous chromosomes have the _____ genes but possibly different alleles. The alleles you inherit may be the same or different.

<p>Homozygous</p>	<ul style="list-style-type: none"> ● Homozygous means you inherited two copies of the _____ allele for the same gene. ● The terms pure, purebred, or true breeding also mean homozygous. ● Homozygous dominant - the dominant trait is expressed when two dominant alleles are inherited. Ex. _____ ● Homozygous recessive - the recessive trait is expressed when two recessive alleles are inherited. Ex. _____
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	<ul style="list-style-type: none"> ● Heterozygous means you inherited two different alleles for the same gene. ● The term hybrid also means heterozygous. ● The dominant trait will always be expressed.
<p>Genes influence the development of traits.</p> 	<ul style="list-style-type: none"> ● A <u>genotype</u> is the version of the alleles that you inherit. Ex. _____ Ss, ss ● A <u>phenotype</u> is the physical expression of the genotype. Ex. _____ or wrinkled. ● What the organism physically looks like.

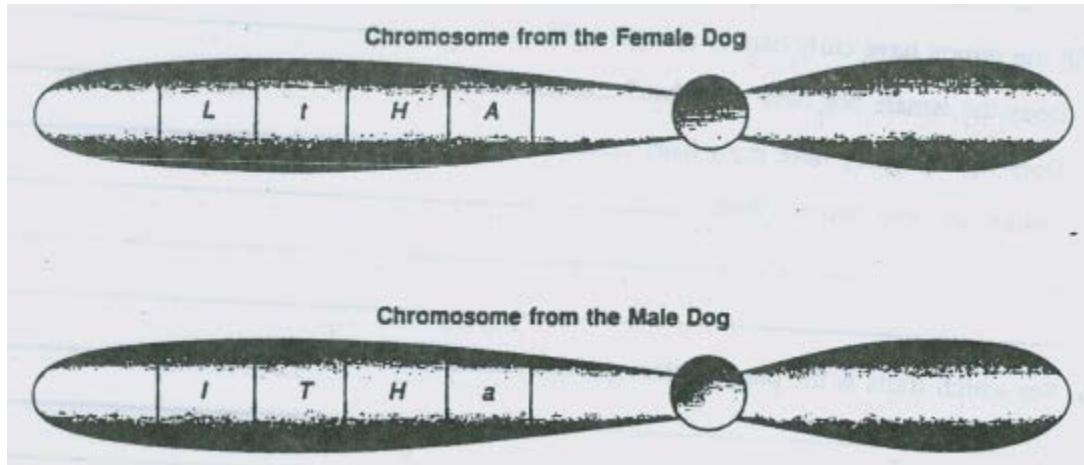
Important Vocabulary

Word	Definition	Example from Mendel's Peas
Allele	A form of a gene that determines traits, represented by uppercase and lowercase letters.	Gene = plant height Tall = T Short = t
Homozygous	When offspring have two alleles that are the same (homo = same)	Homozygous Tall = TT Homozygous Short = tt
Genotype	The alleles that are inherited.	TT, Tt, or tt
Phenotype	Physical trait, what the organism looks like	Tall or short
Heterozygous	When offspring have two alleles that are different (hetero = different)	Heterozygous = Tt
Dominant	Allele that is always expressed when it is present, represented by an uppercase letter	Dominant Allele = T (tall) TT and Tt genotypes will result in a tall plant.
Recessive	Allele that is only expressed when two recessive alleles are present (not expressed when dominant allele is present)	Recessive Allele = t (short) Only the tt genotype will result in a short plant.
P₁ Generation	The parental generation in a breeding experiment	

F₁ Generation	The first generation of offspring in a breeding experiment	
F₂ Generation	The second generation of offspring in a breeding experiment (from breeding individuals from F ₁ generation)	

Should This Dog Be Called Spot?

Imagine this microscopic drama. A sperm cell from a male dog fuses with an egg cell from a female dog. Each dog's gamete carries 39 chromosomes. The zygote that results from the fusion of the gametes contains 78 chromosomes – one set of 39 chromosomes from each parent. One pair of the zygote's chromosomes is shown below.



Each chromosome of the homologous pair contains alleles for the same traits. But one chromosome may have a dominant allele and the other a recessive allele. Use the drawings and the table to answer the questions.

Trait	Dominant Gene	Recessive Gene
Hair Length	Short (L)	Long (l)
Hair Texture	Wiry (T)	Silky (t)
Hair curliness	Curly (H)	Straight (h)
Coat Pattern	Spotted (A)	Solid (a)

1. From which parent did the puppy inherit its coat pattern?

2. Does the female dog have a spotted coat? Explain.

3. Does the male dog have a spotted coat? Explain.

4. What will be the texture of the puppy's coat?

5. Will the texture of the puppy's coat resemble that of either of its parents? Explain.

6. Will the puppy have curly hair or straight hair?

7.
 - a. Does the female dog have curly hair?

 - b. Does the male dog have curly hair?

8.
 - a. Define the term heterozygous.

 - b. For which traits is the puppy heterozygous?

9.
 - a. Define the term homozygous.

 - b. For which traits is the puppy homozygous?

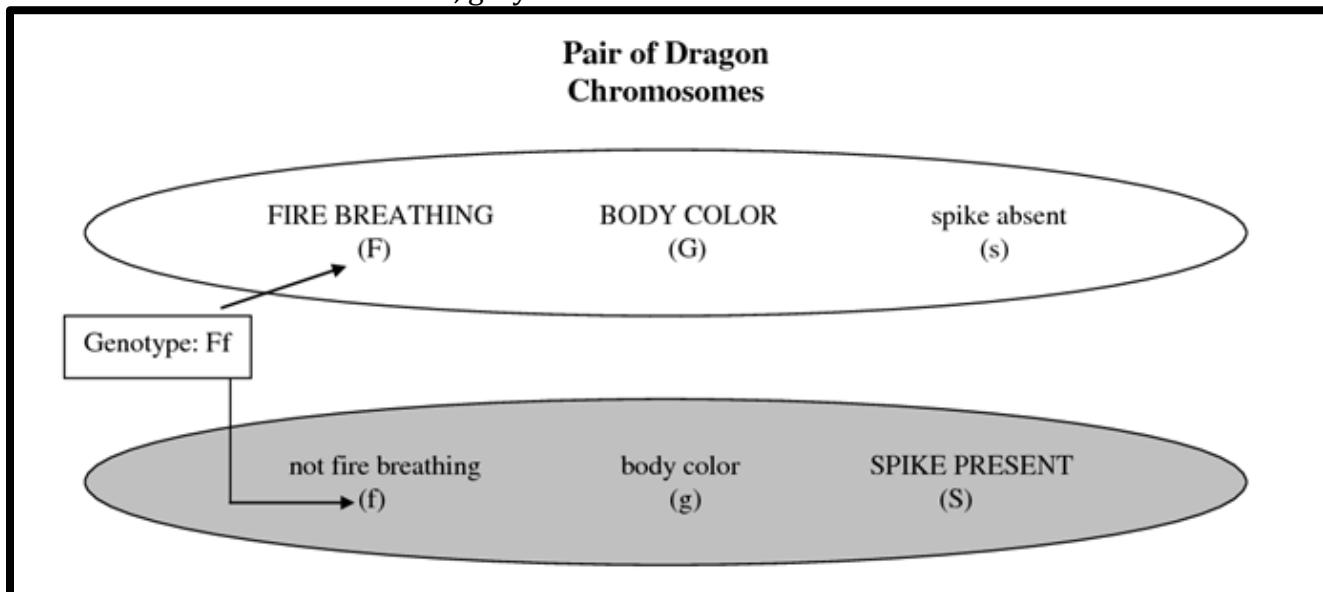
10. Explain why you cannot completely describe the puppy's parents even though you can accurately describe the puppy.

Dragon Key

Upper case letters represent dominant alleles.
Lower case letters represent recessive alleles.

N = LONG NECK n = short neck	E = RED EYE e = white eye
H = HORN PRESENT h = horn absent	F = FIRE BREATHING f = not fire breathing
G = GREEN BODY g = gray body	L = LONG TAIL l = short tail
S = SPIKES ON END OF TAIL s = no spikes on end of tail	R = RED WINGS r = yellow wings
T = THREE TOES t = four toes	W = YELLOW BELLY w = white belly
B = BLACK TAIL SPIKES b = red tail spikes	K = FRECKLES k = no freckles
X = X chromosome/no ear frills (XX = female)	Y = Y chromosome/ear frills present (XY = male)

White chromosome is from mom, gray chromosome is from dad.



Dragon Genetics**I'M ALL KEYED UP**

Use the Dragon Key to answer the following questions.

1. What letters are used to represent wing color? _____
2. What letters are used to represent neck length? _____
3. The letter "Y" is used as a symbol to represent _____. _____
4. The letter "e" is used to represent _____. _____

An uppercase, or capital, letter is used to represent a dominant trait. A lowercase, or small, letter is used to represent a recessive trait. Dominant traits completely mask recessive traits.

5. List 3 dominant traits shown in the key.
 - a.
 - b.
 - c.
6. List 3 recessive traits shown in the key.
 - a.
 - b.
 - c.

WOULD SOMEONE PLEASE TAKE CHARGE?

When offspring inherit traits from their parents, they receive one allele from the mother and one allele from the father. This combination of alleles is called the **genotype**, and the physical appearance or trait is the **phenotype**. For example, the genotype for a long-necked dragon could be either NN or Nn; the phenotype for this trait would be a long neck.

Using the Dragon Key, fill in the missing genotypes and phenotypes.

Trait	Genotype (Allele Symbols)	Phenotype (Physical Appearance)
Neck size	NN or Nn	Long neck
Neck size	nn	Short neck
Spikes on tail?		No spikes
Eye color	EE	
Horn? (present or absent)	hh	
Fire breathing?	_____ or _____	Breathes fire
Belly color	WW or Ww	
Color of spikes		Red
Tail length	_____ or _____	Long

ENTER THE PARENT DRAGONS

Name _____ Block _____ Page # _____

Traits are carried on structures called chromosomes (remember that a chromosome is DNA that has been coiled up very tightly). Using the Pair of Dragon Chromosomes, fill in the following table to determine the genotype and phenotypes of the dragon's offspring.

Trait	Genotype	Phenotype
Fire breathing or not	Ff	Fire breathing
Body Color		
Spikes (present or absent)		

ENTER THE BABY DRAGON

Procedure:

1. Your teacher should have given you either a dragon "egg" or a dragon "sperm" with a number on it. Find the other person in your class who has the matching number. This person is now your "mate."
2. Remove all of the chromosomes from your "egg" and "sperm." Pair up the chromosomes (C#1 from the "egg" and C#1 from the "sperm" go together).
3. Determine your baby dragon's genotype and phenotype for all of the traits listed. Also determine whether your baby dragon is heterozygous or homozygous for each trait. Record the information in the tables below.
4. Using your data table, cut out the correct baby dragon body parts and glue them as directed by your teacher.
5. When you are finished, place all four pink chromosomes back into the "egg" and all four blue chromosomes back into the "sperm."

What number egg and sperm did you and your partner receive? _____

Chromosome pair number	Trait	Genotype	Homozygous/ Heterozygous	Phenotype
1	Neck length			
	Eye color			
	Horn?			
	Spikes?			

Chromosome pair number	Trait	Genotype	Homozygous/ Heterozygous	Phenotype
2	Tail length			

	Body color			
	Color of wings			
	Number of toes			

Chromosome pair number	Trait	Genotype	Homozygous/ Heterozygous	Phenotype
3	Belly color			
	Color of spikes			
	Freckles?			

Chromosome pair number	Trait	Genotype	Homozygous/ Heterozygous	Phenotype
4	Fire breathing?			
	Ear frills?			

Conclusion Questions

1. Name and describe two processes during meiosis that contribute to genetic variation in the baby dragons?
2. Describe one similarity and one difference between the two terms.
 - a. Homozygous and heterozygous
 - b. Genotype and Phenotype

6.5 Traits and Probability

KEY CONCEPT The inheritance of traits follows the rules of probability.

Punnett squares illustrate genetic crosses.

A **Punnett square** is a grid* system for predicting all possible genotypes resulting from a cross. The outside edges, or axes*, of the grid represent the possible genotypes of gametes from each parent. The grid boxes show the possible genotypes of offspring from those two parents.

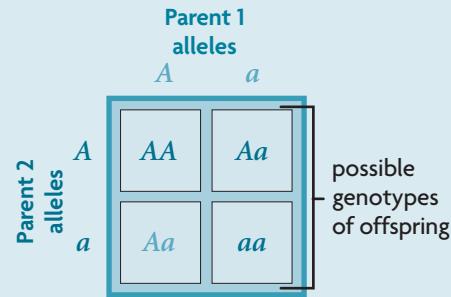
Let's briefly review what you've learned about meiosis and segregation to examine how the Punnett square works. Both parents have two alleles for each gene. These alleles are represented on the axes of the Punnett square. During meiosis, the chromosomes—and therefore the alleles—are separated. Each gamete can receive only one of the alleles, but not both. When fertilization happens, gametes from each parent join together and form a diploid cell with two copies of each chromosome. The new cell has two alleles for each gene. This is why each box shows two alleles. One is from each parent.



What do the letters on the axes of the Punnett square represent? _____

VISUAL VOCAB

The **Punnett square** is a grid system for predicting possible genotypes of offspring.



A monohybrid cross involves one trait.

Thus far, we have studied crosses of one trait. **Monohybrid crosses** are crosses that examine the inheritance of only one specific trait—for example, flower color. If we know the genotypes of the parents, we can use a Punnett square to predict the genotypes of the offspring.

The Punnett squares on the next page show the results of three different crosses:

- Homozygous dominant crossed with homozygous recessive ($FF \times ff$)
- Heterozygous crossed with heterozygous ($Ff \times Ff$)
- Heterozygous crossed with homozygous recessive ($Ff \times ff$)

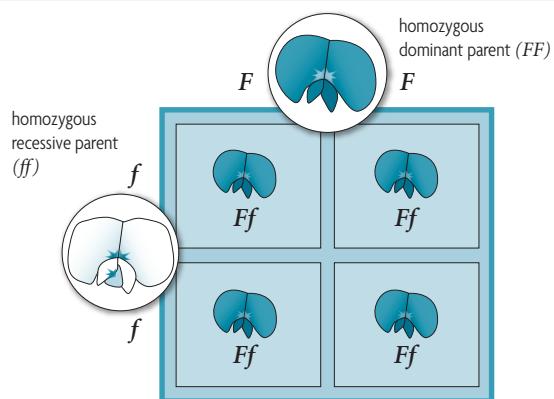
* ACADEMIC VOCABULARY

grid a layout of squares, like on graph paper

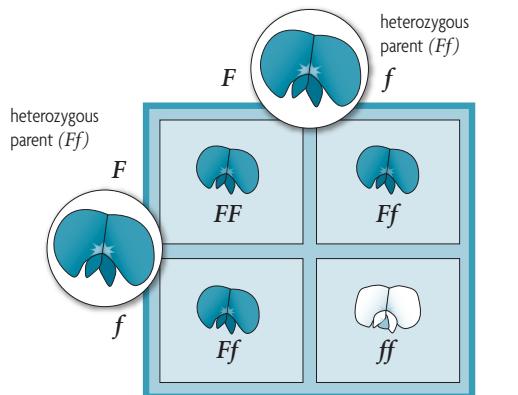
axes lines that act as points of reference

MONOHYBRID CROSSES

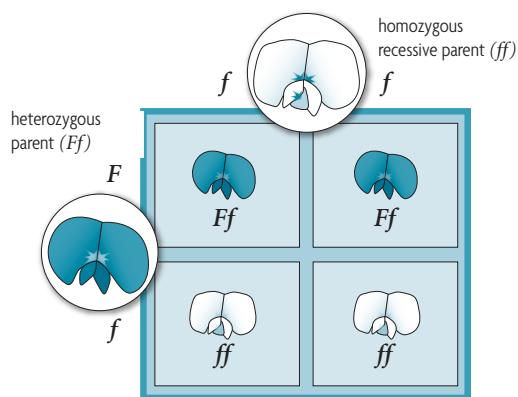
All offspring receive a dominant allele, F , from one parent and a recessive allele, f , from the other parent. So all offspring—100 percent—have the heterozygous genotype Ff . And 100 percent of offspring have purple flowers.



From each parent, half of the offspring receive a dominant allele, F , and half receive a recessive allele, f . Therefore, one-fourth of the offspring have an FF genotype, one-half are Ff , and one-fourth are ff . In other words, the genotypic ratio is 1:2:1 of $FF:Ff:ff$. Remember that both FF and Ff genotypes have a purple phenotype. The phenotypic ratio is 3:1 of purple:white flowers.



All of the offspring receive a recessive allele, f , from the homozygous recessive parent. Half receive a dominant allele, F , from the heterozygous parent, and half receive the recessive allele, f . The resulting genotypic ratio is 1:1 of $Ff:ff$. The phenotypic ratio is 1:1 of purple:white.



Suppose that we had a purple-flowered pea plant but did not know its genotype. It could be FF or Ff . We could figure out its genotype by crossing the purple-flowered plant with a white-flowered plant. We know that the white-flowered plant is ff , because it has the recessive phenotype. If the purple-flowered plant is FF , the offspring will all be purple. If the purple-flowered plant is Ff , half of the offspring will have purple flowers, and half will have white flowers. Crossing a homozygous recessive organism with an organism of unknown genotype is called a **testcross**.



What are the genotypes of offspring from an $FF \times ff$ cross?

A dihybrid cross involves two traits.

So far, we have examined monohybrid crosses, or crosses that examine only one trait. Mendel also performed **dihybrid crosses**, or crosses that examine the inheritance of two different traits.

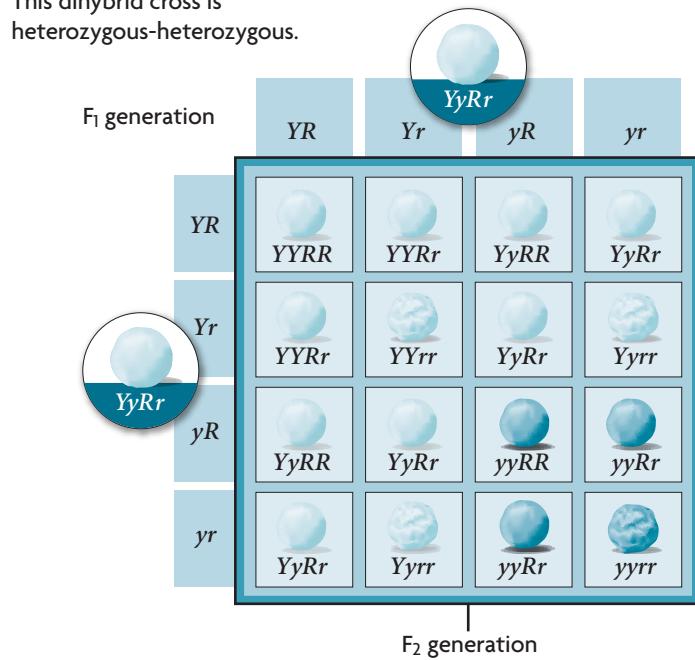
For example, Mendel crossed a purebred plant that had yellow round peas with a purebred plant that had green wrinkled peas. He wanted to see if the two traits—pea shape and color—were inherited together. The first generation of offspring all looked the same, and they were all heterozygous for both traits. The second generation of offspring is shown in the figure to the right. In addition to green wrinkled and yellow round peas, there were also green round and yellow wrinkled peas. In other words, Mendel found that pea shape and color were independent of each other—they were not inherited together. Mendel's second law of genetics is the **law of independent assortment**, which states that alleles of different genes separate independently of one another during gamete formation, or meiosis. Different traits are inherited separately.

VOCABULARY

Mono- means “one,” and *di-* means “two.” A *monohybrid cross* looks at one trait and a *dihybrid cross* looks at two traits.

DIHYBRID CROSS

This dihybrid cross is heterozygous-heterozygous.



What is the difference between a monohybrid cross and a dihybrid cross? _____

Heredity patterns can be calculated with probability.

Probability is the likelihood, or chance, that a particular event will happen. It predicts the average number of times something happens, not the exact number of times.

$$\text{Probability} = \frac{\text{number of ways a specific event can occur}}{\text{number of total possible outcomes}}$$

Suppose you flip a coin. There is a $\frac{1}{2}$ chance it will land on heads, and a $\frac{1}{2}$ chance that it will land on tails. Suppose you flip two coins. For each one, the chance it will land on heads is $\frac{1}{2}$. But for both to land on heads, the chance is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$.

These probabilities can be applied to meiosis, too. Suppose a germ cell has heterozygous alleles for a trait, for example, *Ff*. A gamete has a $\frac{1}{2}$ chance of getting an *F* and a $\frac{1}{2}$ chance of getting an *f*. If two heterozygous plants are crossed, what is the chance that the offspring will be *FF*? There is a $\frac{1}{2}$ chance that the sperm will carry an *F* and a $\frac{1}{2}$ chance that the egg will carry an *F*. Therefore, there is a $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ chance that the offspring will be *FF*. Probability can be used to determine all of the possible genotypic outcomes of a cross.

PROBABILITY AND HEREDITY

The coins are equally likely to land heads up or tails up.



$\frac{1}{2} H$



Two sides of coin 2

$\frac{1}{2} T$



Two sides of coin 1



$\frac{1}{4} HH$



$\frac{1}{4} HT$



$\frac{1}{4} HT$



$\frac{1}{4} TT$

 If you flip two coins, what is the probability that they will both land on tails?

6.5 Vocabulary Check

Punnett square	dihybrid cross
monohybrid cross	law of independent assortment
testcross	probability

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.



Choose the correct term from the list for each description.

- crossing an organism of unknown genotype with a homozygous recessive organism _____
- a cross to examine one trait only _____
- a cross to examine two different traits _____

6.5 The Big Picture

- Fill in the Punnett square and list the genotype and phenotype ratios.

Genotype ratio: _____

Phenotype ratio: _____

	<i>F</i>	<i>f</i>
<i>f</i>		<i>Ff</i>
<i>f</i>		

Name: _____ Class: _____ Date: _____

Section 5: Traits and Probability

PowerNotes

Punnett Square

- Axes:
- Grid boxes:

Ratios:

-
-

Monohybrid cross:

Testcross: _____

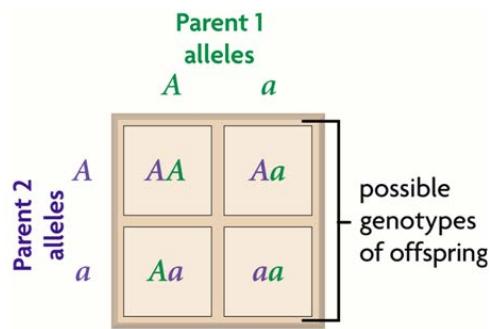
Dihybrid cross:

Ratios:

-
-

Law of independent assortment:

Probability:

Notes - Punnett Squares**Key Concept:**

What is probability? Probability is the _____ that a particular event will happen.

Using a Punnett Square

Step 1: Draw a box and divide it in 4 parts.

Step 2: Label the top and left side of the box with the genotypes of the parents.

Parents: Rr x Rr

Step 3: Place two letters in the middle boxes (one from the top and one from the left).

How many offspring would you expect to be round?

How many offspring would you expect to be wrinkled?

Ratio of Genotypes: _____ RR: _____ Rr: _____ rr

Ratio of Phenotypes: _____ Round: _____ Wrinkled

Punnett Square - Practice

- Cross a female with straight hair (HH) and a male with curly hair (hh).

_____ HH: _____ Hh: _____ hh

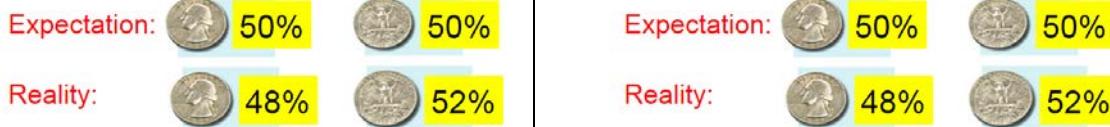
_____ Straight: _____ Curly

- Cross a black dog (Bb) and a brown dog (bb).

_____ BB: _____ Bb: _____ bb _____ Black: _____ Brown	
3. Cross a yellow corn (Yy) and another yellow corn (Yy). (y = white corn) _____ YY: _____ Yy: _____ yy _____ Yellow: _____ White	

Expectation vs. Reality

Probabilities do NOT predict the _____ (expectation) number of occurrences. They predict the _____ (reality) number of occurrences

Suppose you flip a coin 100 times. You would expect to get _____ heads and _____ tails, but your actual results may be _____ heads and _____ tails.	 Expectation: Two coins, one head up (blue box) and one tail up (yellow box), both labeled 50%. Reality: Two coins, one head up (blue box) and one tail up (yellow box), labeled 48% and 52% respectively.
---	---

A cross between two parents (Rr x Rr) results in the following offspring: 25% RR, 50% Rr, 25% rr. If these parents had 100 offspring, how many would you expect to be rr? _____.

Remember, this is what you would expect. If they actually had 100 offspring, the actual number may be different.

- In humans, sex determination is genetic.
 - Females (_____) = 50%
 - Males (_____) = 50%
- Suppose a family has had 7 children, and all of them are boys.
 - What is the probability of the next child being a girl? ____ %
- The larger the population, the closer you get to the expected results.
 - Family (population 10) = 80% male, 20% female
 - United States (population 300 mil) = 49.2% males, 50.8% female

	X	X
X	XX	XX
Y	XY	XY

Notes - Dihybrid Crosses**Key Concept:**

Monohybrid Cross	Dihybrid Cross
Rr x Rr	RrYy x RrYy

Texture: R = round, r = wrinkled

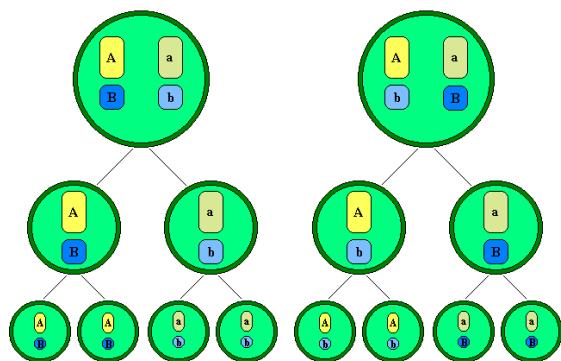
Color = Y = yellow, y = green

Law of Independent Assortment

The Law of Independent Assortment states that allele pairs _____

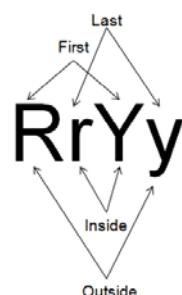
_____ of each other during gamete formation, or meiosis..

appear to be _____.

**How can you find the possible gametes for a dihybrid cross?**You can use **FOIL** (_____, _____, _____, _____) to predict possible gametes that can come from each parent.

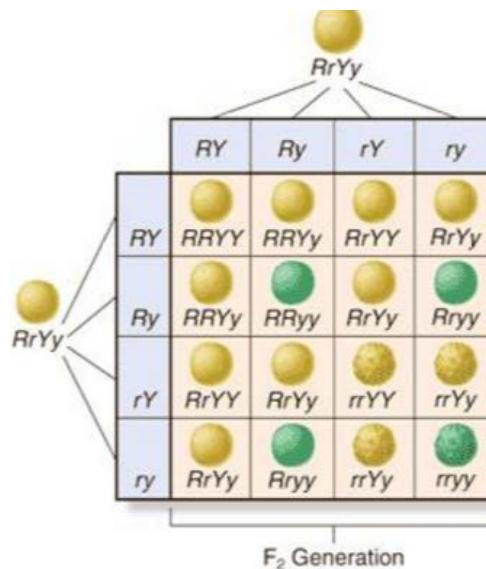
If a parent's genotype is AaBb, the possible gametes are...

first outside inside last

**How to solve a dihybrid cross:**

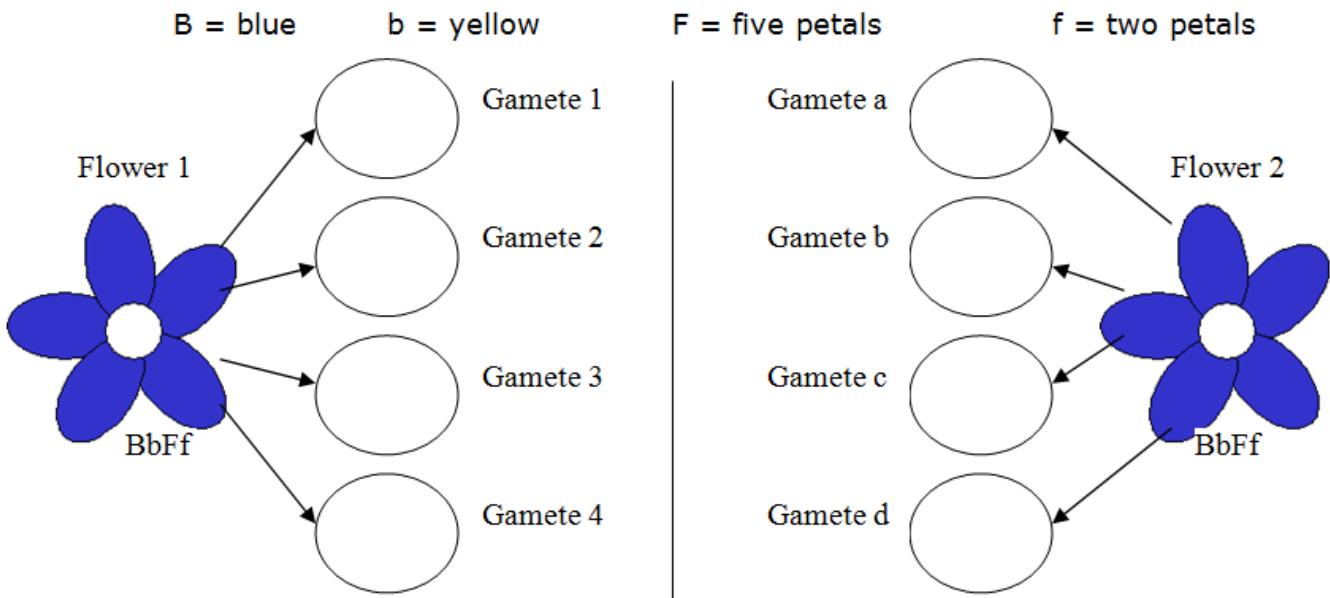
FOIL helps you determine the possible gametes, but you also have to be able to _____ the possible _____ of crossing these gametes.

The outcomes of _____ crosses can be predicted using punnett squares.



Dihybrid Cross Practice

1. Use FOIL to determine the parent's gametes.



2. Draw a 4x4 punnett square grid. (If not provided)

3. Write the parent's genotypes for each gamete on the top and side of the dihybrid cross grid.

4. Complete the dihybrid cross.

Possible gametes from parent 1 →	Gamete 1	Gamete 2	Gamete 3	Gamete 4
Possible gametes from parent 2 ↓				
Gamete a				
Gamete b				
Gamete c				
Gamete d				

5. Count the genotypes of the offspring.

Genotypes**Phenotypes**

_____ : BBFF _____ : Bbff

_____ : Blue, five petals

_____ : BBFf _____ : bbFF

_____ : Yellow, five petals

_____ : BBff _____ : bbFf

_____ : Blue, three petals

_____ : BbFF _____ : bbff

_____ : Yellow, three petals

_____ : BbFf

Steps for Solving a Dihybrid Cross (Quick version)

The outcomes of dihybrid crosses can also be predicted using 2 punnett squares and a little math.

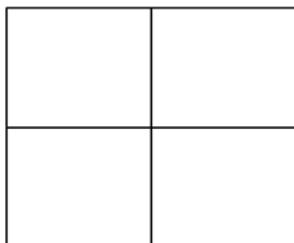
1. Write the genotype of each parent.
2. Draw two punnett squares (one for each trait or letter)
3. Complete the punnett squares.
4. Determine fractions and multiply to answer the questions.

Dihybrid Cross - Practice

R = round, r = wrinkled; Y = yellow, y = green

A parent that is heterozygous for both traits is crossed with a parent that is homozygous recessive for both traits. How many of their offspring will be RrYy?

Parents: _____ x _____



Rr = _____ or _____

Yy = _____ or _____

_____ x _____ = _____

RrYy = _____ or _____ %

Monohybrid Cross Practice**Part A: Vocabulary**

Match the definitions on the left with the terms on the right.

- | | |
|--|-----------------|
| 1. Genotypes made of the same alleles | A. alleles |
| 2. Different forms of genes for a single trait | B. dominant |
| 3. Gene that is always expressed | C. heterozygous |
| 4. Gene that is expressed only in the homozygous state | D. homozygous |
| 5. Genotypes made of two different alleles | E. recessive |

Below each of the following words are choices. Circle the choices that are examples of the term given.

6. Dominant allele

D e k L N n R S

7. Recessive allele

M n d F G r k P

8. Homozygous dominant

AA Gg KK mm uu Rr TT

9. Homozygous recessive

ee Ff HH Oo qq Uu ww

10. Genotypes in which dominant gene must show

AA Dd EE ff Jj RR Ss

11. Genotypes in which recessive gene must show

aa Gg Ff KK rr Oo Tt

Part B: Punnett Squares

12. Examine the following Punnett squares and *circle those that are correct*.

		D	d
d	Dd	dd	
d	Dd	dd	

		D	D
d	Dd	DD	
d	Dd	Dd	

		A	a
A	AA	aa	
a	Aa	Aa	

		A	a
a	Aa	aa	
a	Aa	aa	

13. What do the letters on the outside of the Punnett square represent?

14. What do the letters on the inside of the Punnett square represent?

15. Complete these four Punnett squares showing different crosses.

N	N
n	
n	

N	n
N	
N	

N	n
n	
n	

N	n
n	
n	

16. In guinea pigs, short hair, S, is dominant to long hair, s. Complete the following.

- a. One guinea pig is Ss and the other is ss.

What percentage of the offspring will be:

_____ Short hair (SS or Ss)

_____ Long hair (ss)

- b. Both guinea pigs are *heterozygous* for short hair.

What percentage of the offspring will be:

_____ Short Hair

_____ Long Hair

Part C: Monohybrid Cross Problems

17. Hornless (H) ini cattle is dominant over horned (h). A homozygous hornless bull is mated with a homozygous horned cow. What will be the genotypes and phenotypes of the first generation?

Genotype:

Phenotype:

18. In humans, being a tongue roller (R) is dominant over a non-roller (r). A man who is a non-roller marries a woman who is heterozygous for tongue rolling.

Father's phenotype:

Father's genotype:

Mother's phenotype:

Mother's genotype:

Probability of this couple having a child who is a tongue roller:

19. In tomatoes, red fruit (R) is dominant over yellow fruit (r). A plant that is homozygous for red fruit is crossed with a plant that has yellow fruit.

P1 Genotypes:

P1 Phenotypes:

F1 Genotype:

F1 Phenotype:

20. If two of the F1 generation from the above cross were mated, what would be the genotypes and phenotypes of the F2 generation?

F2 Genotypes:

F2 Phenotypes:

21. Brown eyes in humans are dominant to blue eyes. A brown-eyed man, whose mother was blue-eyed, marries a brown-eyed woman whose father had blue eyes. What is the probability that this couple will have a blue-eyed child?

Probability of having a blue-eyed child:

22. In rats, black is dominant over white. A homozygous black rat (B) is crossed with a homozygous white one (b).

Probability of white rats in F1:

Probability of black rats in F1:

Genotype of F1:

23. A heterozygous tall plant (T) is crossed with a short one (t).

Phenotypic ratio for F1:

Genotypic ratio for F1:

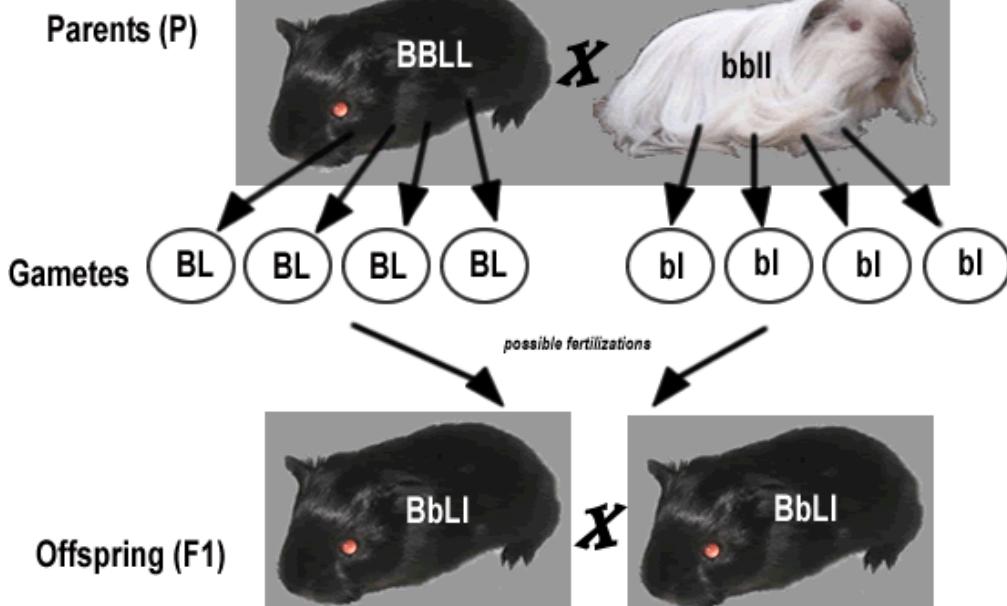
24. Heterozygous black rabbits (B) carry the gene for albinism (b). If two of these heterozygous rabbits are crossed...

Phenotypic ratio of F1 offspring as a %.

Genotypic ratio of F1 offspring as a %.

DIHYBRID CROSS

Name _____



A cross (or mating) between two organisms where two genes are studied is called a DIHYBRID cross.

The genes are located on separate chromosomes, so the traits themselves are unrelated.

BB = black

Bb = black

bb = white

LL = short hair

LI = short hair

II = long hair

		Female Gametes			
		BL	BI	bL	bl
Male Gametes	BL				
	BI				
	bL				
	bl				

Fill out the genotypes of each of the offspring to determine how many of each type of offspring are produced.

Phenotypic ratios - How many, out of 16 are:



Black, Short



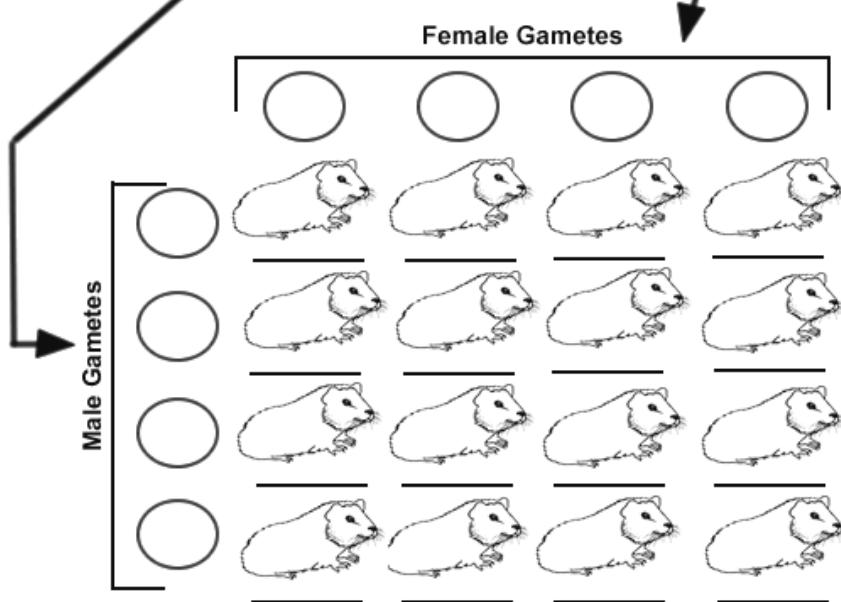
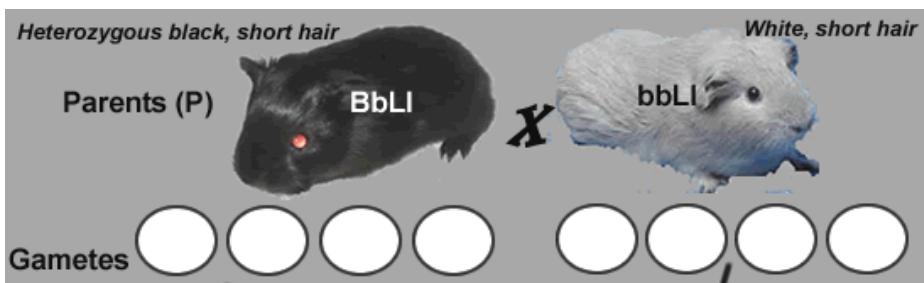
Black, Long



White, Short



White, Long



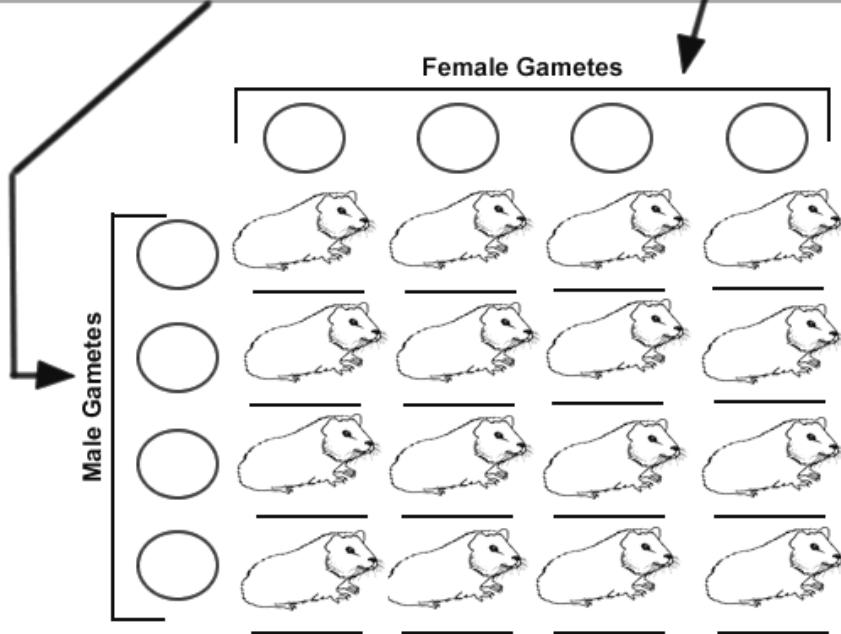
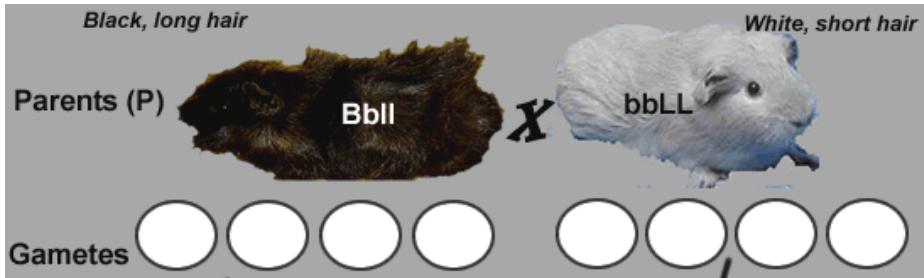
How many of the offspring are:

Black, Short _____

Black, Long _____

White, Short _____

White, Long _____



How many of the offspring are:

Black, Short _____

Black, Long _____

White, Short _____

White, Long _____

7.2 Complex Patterns of Inheritance

KEY CONCEPT Phenotype is affected by many different factors.

Phenotype can depend on interactions* of alleles.

In many cases, alleles are not simply dominant or recessive. Alleles may interact in many different ways. For example, alleles might have a range of dominance. There might be more than just two alleles for a gene. Or there might be many different genes that all affect one trait.

Incomplete Dominance

Sometimes, neither allele is completely dominant or completely recessive. In this case, the heterozygous phenotype is somewhere between the two homozygous phenotypes. In other words, the alleles show **incomplete dominance**. One example of incomplete dominance is the flowers of the four o'clock plant. When plants that are homozygous for red flowers are crossed with plants that are homozygous for white flowers, the offspring have pink flowers. Neither of the phenotypes of the parents can be seen separately in the offspring.

VISUAL VOCAB

When alleles are neither dominant nor recessive, such as with incomplete dominance, uppercase letters with either subscripts— F_1 —or superscripts— F^2 —are used to represent the different alleles.

GENOTYPE	F_1F_1	F_1F_2	F_2F_2
PHENOTYPE	red flowers	pink flowers	white flowers

The flower colors of the four o'clock plant show incomplete dominance. Heterozygous plants have a phenotype in between the two homozygous plants.

Codominance

Sometimes, both alleles of a gene are expressed completely, and neither is dominant or recessive. In this case, alleles show **codominance**. With incomplete dominance, recall that the heterozygous flowers were pink—a blend of the two homozygous phenotypes. Codominance is different because both traits are expressed separately. The heterozygous phenotype would have some red areas and some white areas.

* ACADEMIC VOCABULARY

interaction two or more things working together

Human blood types are an example of codominance. Blood type is also a multiple-allele trait, because there are three different alleles. The three alleles are called I^A , I^B , and i . Both I^A and I^B produce a protein called an antigen on the surface of red blood cells. I^A and I^B are codominant. Allele i is recessive and does not produce an antigen. Four different phenotypes are possible, shown in the figure to the right.



What is the difference between incomplete dominance and codominance? _____

CODOMINANCE		
PHENOTYPE (BLOOD TYPE)		GENOTYPES
A	antigen A	I^A/I^A or I^A/i
B	antigen B	I^B/I^B or I^B/i
AB	both antigens	I^A/I^B
O	no antigens	ii

Many genes may interact to produce one trait.

As you have seen, some phenotypes are a result of incomplete dominance, codominance, and multiple alleles. But most traits in plants and animals, including humans, are the result of several genes that interact.

Polygenic Traits

Traits produced by two or more genes are called **polygenic traits**. For example, eye color and skin color are both determined by the interaction of multiple genes. At least three genes affect eye color. Each gene has two alleles. Scientists think that there may be even more genes that affect eye color.

Epistasis

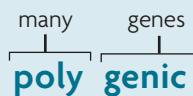
Fur color in mice and other mammals is also a polygenic trait. In mice, at least five different genes interact to produce the fur color phenotype. One of the genes is called an epistatic gene. This gene can prevent the expression of all of the other genes. Albinism—the lack of pigment* in skin, hair, and eyes—is the result of epistasis. If a mouse is homozygous for the alleles that prevent pigmentation, the fur will be white no matter what alleles the mouse has for the other four genes. Albinism occurs in humans, too.



What is the difference between a multiple-allele trait and a polygenic trait? _____

VISUAL VOCAB

Traits that are produced by two or more genes are called **polygenic traits**.



GENE NAME	DOMINANT ALLELE	RECESSIVE ALLELE
BEY1	brown	blue
BEY2	brown	blue
GEY	green	blue

At least three different genes interact to produce the range of human eye colors.

* ACADEMIC VOCABULARY

pigment dye, or something that causes color

The environment interacts with genotype.

Phenotype is not determined only by genes. The environment—the conditions surrounding an organism—also affect phenotype. For example, the sex of sea turtles depends on the temperature of the environment in which the egg develops. Female turtles make nests on beaches and bury their eggs in the sand. Eggs that are in warmer parts of the nest become female. Eggs in cooler parts become male.

Genes and environment also interact to determine human traits. For example, genes influence height, but they do not completely control height. One way scientists study the interaction between genes and the environment is by comparing twins raised in different environments. Identical twins can have height and size differences depending on environmental conditions such as nutrition and health care.



Why might genetically identical twins have different phenotypes?

7.2 Vocabulary Check

incomplete dominance
codominance

polygenic trait

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.



Match the correct term from the list to each example below.

1. Eye color, which is determined by at least three genes, is an example of _____
2. The flowers of a heterozygous four o'clock plant are pink, which is between the flower color of each homozygous plant. This is an example of _____
3. Human blood type is determined by a protein, called an antigen, on the surface of red blood cells. Someone with both the I^A and I^B alleles will have both the A and B antigens on their red blood cells. This is an example of _____

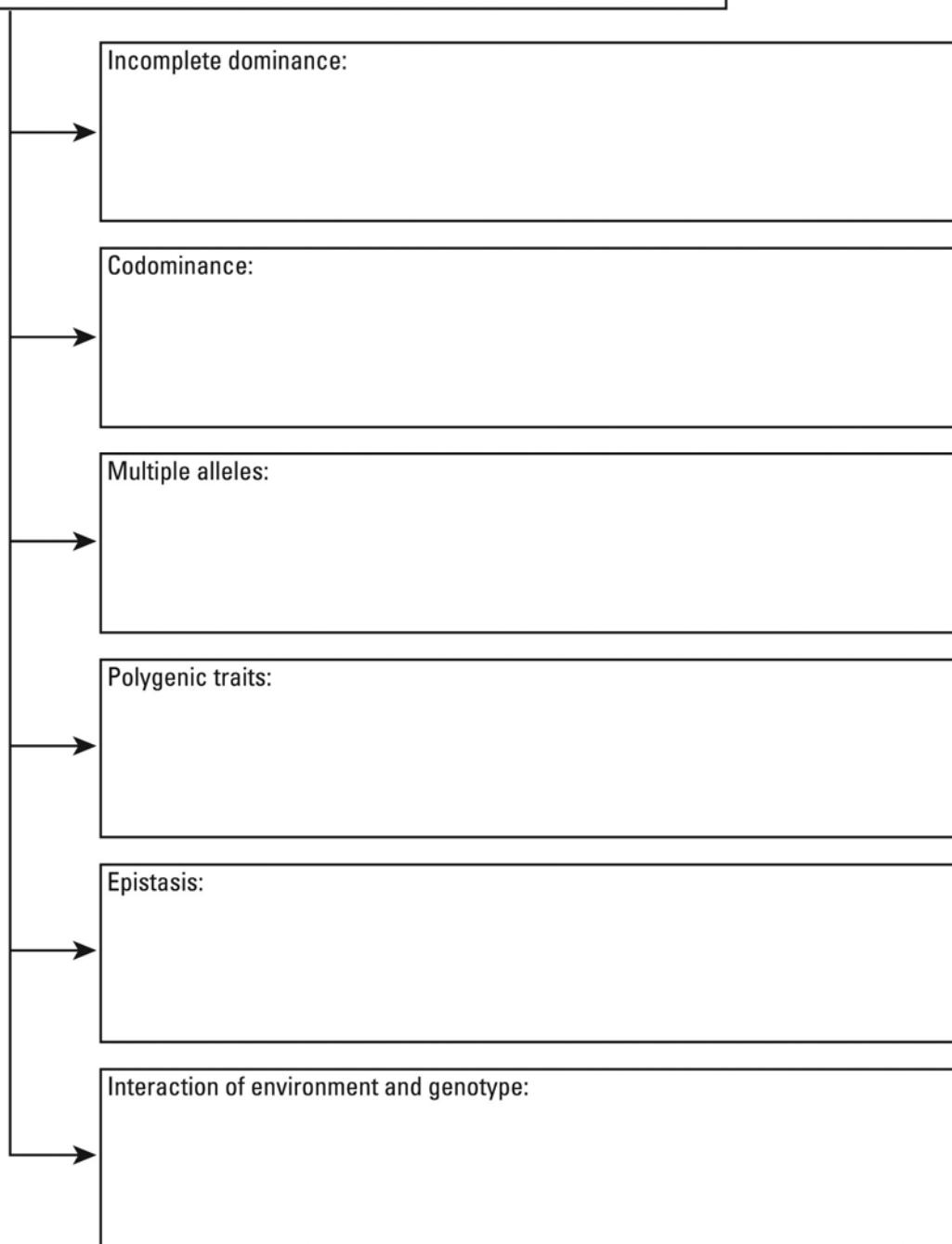
7.2 The Big Picture

4. List at least three patterns of inheritance that are different than the dominant-recessive pattern of Mendel's peas. _____

Section 2: Complex Patterns of Inheritance

PowerNotes

Complex Patterns of Inheritance



Notes - Complex Patterns of Inheritance

Key Concept: _____

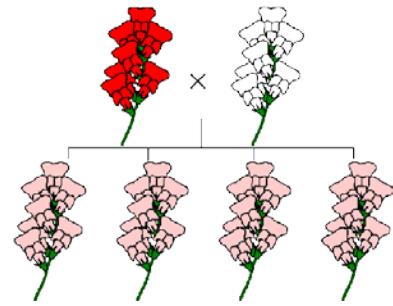
Incomplete Dominance - neither allele is completely dominant, so the _____ have a _____ of the two alleles.

Examples

- Four-O'Clock Flower (color picture to the right)

- _____ + _____ = _____
- Red = $C^R C^R$
- White = $C^W C^W$
- Pink = $C^R C^W$

	C^R	C^R
C^W	$C^R C^W$	$C^R C^W$
C^W	$C^R C^W$	$C^R C^W$

**Incomplete Dominance - Practice**

If tail length in cats is an incompletely dominant trait, what are the genotypes of long, medium, and short-tailed cats?

Allele for long tail = T^L Allele for short tail = T^S

Genotypes: Long _____ Medium _____ Short _____

Two cats with medium tails are crossed. Using a punnett square, predict the genotypes/phenotypes of their offspring.

Parents _____ x _____

Offspring	
Genotype	Phenotype

Codominance - _____

- Cow coat color exhibits codominance. C^B represents the brown coat allele, and C^W represents the white coat allele. What are the genotypes for each type of cow?

- Brown = _____
- White = _____
- Spotted = _____



- Cross two spotted coat cows in the Punnett square below.
- Fill in the genotypes and phenotypes in the table below.

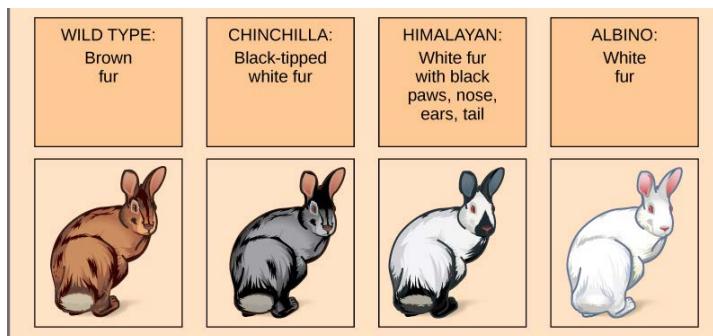
Genotype	Phenotype

Multiple Alleles Trait - _____

- An individual still only receives _____ alleles, but there are more alleles to choose from.
- Since there are _____ allele possibilities, there will also be more _____ and _____ possibilities.

Example: Rabbits have 4 different alleles for the gene for coat color!

- C = brown
- c = albino (white)
- c^{ch} = chinchilla (white fur with black tips)
- c^h = himalayan (white fur with black accents)



Example: Human Blood Types

- A allele = I^A (codominant with I^B)
- B allele = I^B (codominant with I^A)
- O allele = i (recessive)

Phenotype	Genotype(s)?
A	
B	
AB	
O	

A mother has type AB blood and the father has type O. Draw the Punnett Square

- What is the probability of having a child with type A? _____ %
- Can they have a child with type O? _____

A mother is $I^A i$ and the father is $I^B I^B$. Draw the Punnett Square

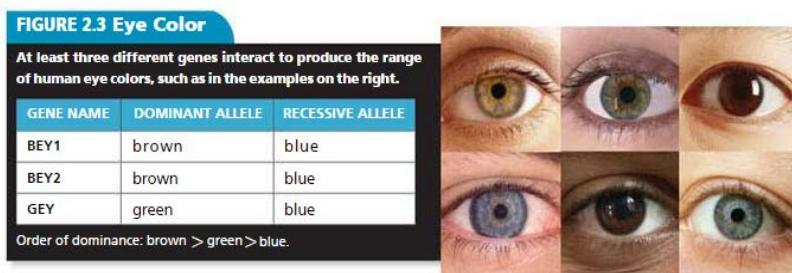
- What is the probability of an offspring being $I^A I^B$? _____ %
- Can they have a child with type A? _____

If a child has AB blood which of the following could NOT be the parents?

- $I^A i$ () + $I^B i$ () = _____
- $I^A i$ () + $I^B I^B$ () = _____
- $I^A I^A$ () + $I^B I^B$ () = _____
- $I^A I^B$ () + ii () = _____

Polygenic Trait _____

Examples: eye color, height, skin color



If a trait is polygenic, it will _____ the number of possible _____ and _____.

Multiple Alleles Practice

Blood Type is controlled by 3 alleles: A, B, O. Alleles A and B are co-dominant while O is recessive. (When you work problems be sure to use I^A , I^B and i for genotypes.)

1. What are the two genotypes possible for a person who has A blood? _____
2. What genotype does a person with AB blood have? _____
3. What genotype does a person with O blood have? _____
4. What are the two genotypes possible for a person who has B blood? _____
5. A man with type AB blood is married to a woman also with type AB blood. Draw and complete a Punnett Square. _____

What **percentage (%)** of their children will have:

A blood? _____ B blood? _____ O blood _____ AB blood _____

6. A man with homozygous type B blood is married to a woman with type O blood. Draw and complete a punnett square.

What is the genotype of the children? _____

What blood type will all their children have? _____

7. A woman with heterozygous type A blood is married to a heterozygous type B person. What are the genotypes of the parents? _____ x _____
Complete the punnett square below.

What is the **probability (%)** their children will have:

A blood? _____ B blood? _____ O blood _____ AB blood _____

8. A woman with type A blood is claiming that a man with type AB blood is the father of her child who is type B. Show all possible Punnett Squares for this couple. Hint: There are 2 possible squares. _____

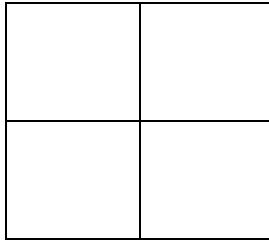
Could this man be the father of the child? _____

9. A man with type AB blood is married to a woman with type O blood. They have two natural children and one adopted child. Draw the punnett square below.

Jane has type A blood, Bobby has type B blood, and Grace has type O blood. Which child was adopted? _____

Practice - Incomplete Dominance and Codominance

1. Define incomplete dominance:
2. In snapdragons, flower color is controlled by incomplete dominance. The two alleles are red (C^R) and white (C^W). The heterozygous phenotype is expressed as pink.
 - a. What is the phenotype of a plant with the genotype $C^R C^R$? _____
 - b. What is the phenotype of a plant with the genotype $C^W C^W$? _____
 - c. What is the phenotype of a plant with the genotype $C^R C^W$? _____
3. A pink-flowered snapdragon is crossed with a white-flowered snapdragon. Show the parents and work the square below. Parents _____ \times _____.



What is the probability of producing a pink-flowered plant? _____ %

In ducks, when a duck with a yellow beak mates with a duck with a red beak they produce ducks with orange beaks. (Use B^R for the red allele and B^Y for the yellow allele.)

4. What is the genotype for:
 - a. red beak ducks? _____
 - b. yellow beak ducks? _____
 - c. orange beak ducks? _____
5. A red beak duck mates with a duck with an orange beak. Show the parental genotypes and set up the Punnett Square below.

Parents _____ \times _____

6. What is the genotypic ratio of the possible offspring? _____
What is the phenotypic ratio of the possible offspring? _____
7. In this breed of ducks, what color beak is dominant? Explain.

8. Define codominance:

9. In some chickens, the gene for feather color is controlled by codominance. The allele for black is F^B and the allele for white is F^W . The heterozygous phenotype is known as erminette.

- What is the genotype for black chickens? _____
- What is the genotype for white chickens? _____
- What is the genotype for erminette chickens? _____

10. Two erminette chickens were crossed.

- Parents: _____ x _____

- What is the probability of having a black chick? _____ %
- What is the probability of having a white chick? _____ %

11. A black chicken and a white chicken are crossed.

- Parents: _____ x _____

- What is the probability that they will have erminette chicks? _____ %

12. Describe the difference between incomplete and codominance in a complete statement.

Whose Baby is it?

Background Information : Three couples arrived at the hospital emergency room at the same time. All the women were in labor and had to be rushed to the delivery room. The chaos during the deliveries resulted in a mix-up of the babies! Each woman had a set of fraternal twins.

Parent - Phenotypes	Babies - Phenotypes
Mr. Smith - brown eyes, B blood Mrs. Smith - brown eyes, A blood	Baby #1 - brown eyes, AB blood Baby #2 - blue eyes, A blood
Mr. Martin - blue eyes, AB blood Mrs. Martin - blue eyes, B blood	Baby #3 - blue eyes, O blood Baby #4 - blue eyes, AB blood
Mr. Garcia - brown eyes, AB blood Mrs. Garcia - blue eyes, O Blood	Baby #5 - brown eyes, B blood Baby #6 - brown eyes, A blood

Mission : Use Punnett squares to determine which babies belong to which set of parents. For each couple, make a Punnett square for eye color and for blood type (You may need to make more than one Punnett square for a trait to test all possible combinations).

Data (Part 1):

Write the correct genotypes for eye color for the given phenotypes. B = brown eyes; b = blue eyes

1. Brown eyes = _____ or _____
2. Blue eyes = _____

Write the correct genotypes for the given phenotypes for blood type.

$$I^A = \text{A allele} \quad I^B = \text{B allele} \quad i = \text{O allele}$$

1. Type A blood = _____ or _____
2. Type B blood = _____ or _____
3. Type AB blood = _____
4. Type O blood = _____

Data (Part 2): Use the space provided to make all of the possible Punnett squares for each family. At the bottom of each section, circle the phenotypes that the offspring could have.

Name _____ Block _____ Page # _____

Smith's Eye Color	Smith's Blood Type
Blue eyes Brown eyes	AB A B O
Martin's Eye Color	Martin's Blood Type
Blue eyes Brown eyes	AB A B O
Garcia's Eye Color	Garcia's Blood Type
Blue eyes Brown eyes	AB A B O

Conclusions:

1. The Garcia's are the parents of babies # _____ and # _____
2. The Martin's are the parents of babies # _____ and # _____
3. The Smith's are the parents of babies # _____ and # _____

More Practice:

In humans, blood type is a trait determined by multiple alleles.

1. Make a Punnett square to show the cross between a woman with Type O blood and a man with Type A blood (homozygous).

a. What are the possible genotypes? _____

b. What are the possible phenotypes? _____

2. Make a Punnett square to show the cross between a woman with type B blood (heterozygous) and a man with type A blood (heterozygous).

a. What are the possible genotypes? _____

b. What are the possible phenotypes? _____

3. Make a Punnett square to show the cross between two people with type AB blood.

- a. What are the possible genotypes? _____

b. What are the possible phenotypes? _____

4. In the space below, make Punnett squares to show all the possible crosses between two people with blood type B. (HINT: There should be three Punnett squares.)

5. Why is there no ABO blood type?

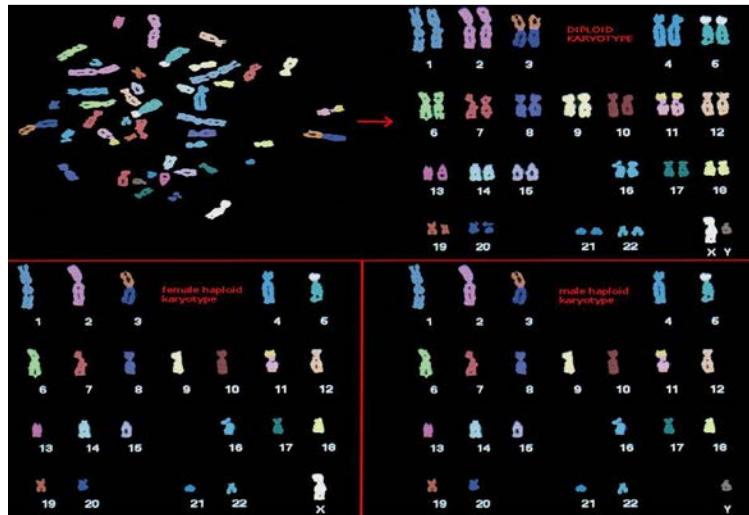
6. Is it possible for two type A parents to produce children who are not type A? Explain using punnett squares to support your answer.

Notes: Karyotypes and Chromosomal Analysis**Key Concept:****How do scientists study the genome?****Karyotyping**

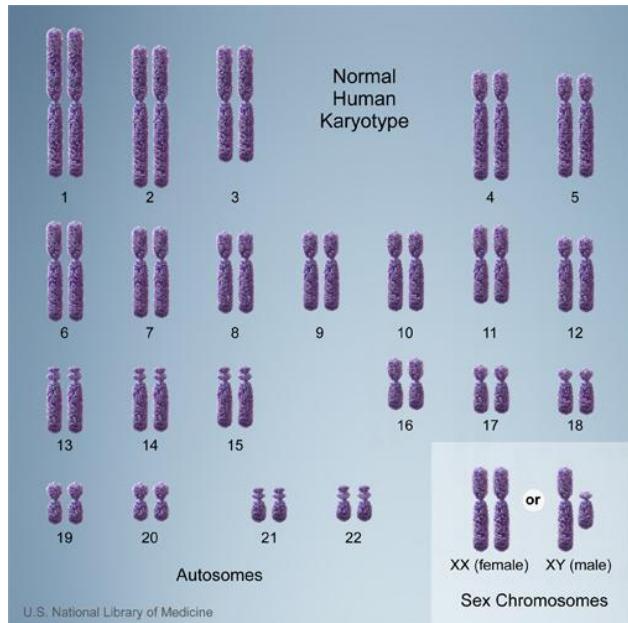
Scientists look at _____ of an individual's chromosomes and compares them with other chromosomes to identify _____.

**What is a karyotype?**

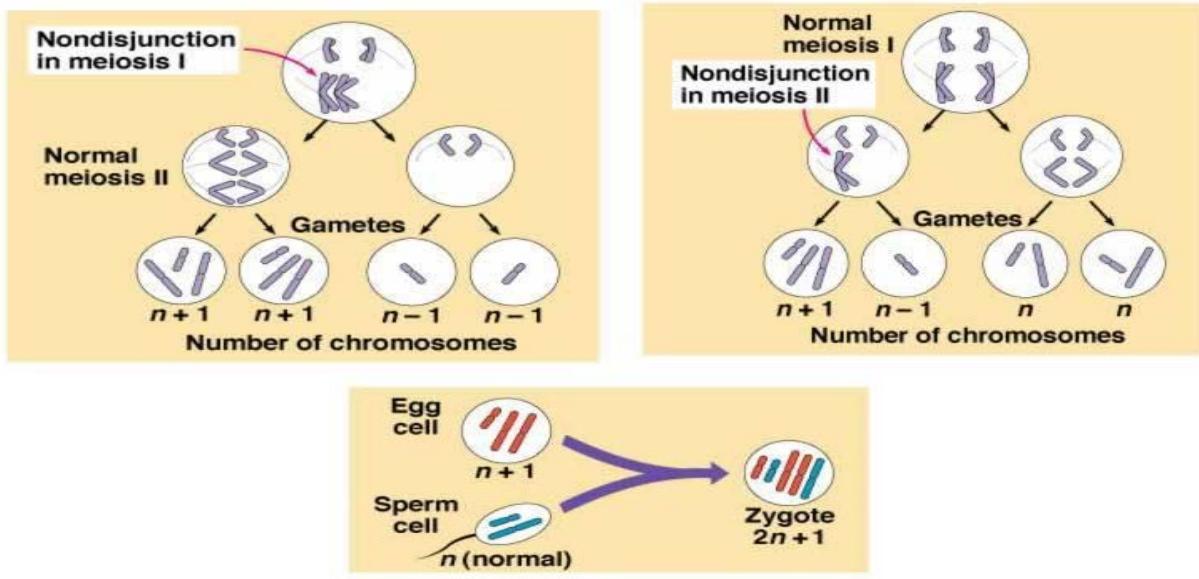
- A karyotype is a picture of chromosomes found in a typical _____ body cell.
- The human _____ contains 46 chromosomes.
- Each parent contributes _____ chromosomes - 23 from _____ and 23 from _____.



- The chromosomes in a human karyotype are arranged in _____.
- The first 22 pairs (44 chromosomes) are called _____.
- The 23rd pair are known as the sex chromosomes.

**Chromosomal Mutations**

- Changes in the number of _____ is caused by _____.
- Nondisjunction occurs during meiosis, when _____ chromosomes or sister _____ fail to separate.
- Non disjunction means “not coming apart”.
 - When nondisjunction occurs, it results in an _____ number of chromosomes in the gametes (sperm or egg), and a chromosomal disorder may result.



Chromosomal Disorders - All caused by nondisjunction!!!!

Disorder	Defect	Symptoms
Patau Syndrome	Trisomy 13	Cleft lip or palate, clenched hands, close set eyes, decreased muscle tone, extra fingers or toes, seizures, intellectually disabled.
Edward's Syndrome		Kidney malformations, structural heart defects, intestines protruding outside body, feeding and breathing difficulties.
Down's Syndrome	Trisomy 21	*Have delayed mental and social development. *Impulsive behavior. *Short attention span. *Slow learning *Short stature
Turner's Syndrome		*May be intellectually disabled, some have normal IQ. *Short stature. *Sterile *Webbed neck. *Underdeveloped breasts and ovaries.
Klinefelter's Syndrome		*Underdeveloped testes. *Inability to produce sperm. *Muscle structure, fat and hair distribution similar to that of a female. *Breasts develop.
Double Y syndrome		Less than average IQ, tall, high hormone levels.

- **Chromosomal Mutations:** involve changes in the _____ or _____ of chromosomes.
- Such mutations may change the locations of genes on chromosomes, and may even change the _____ of copies of some genes.
- Chromosomal mutations occur during crossing over - the _____ of genetic material between homologous pairs of chromosomes.
- Most mutations are _____ - they do not change the expression of genes or _____.
- Some mutations are _____. Some mutations are beneficial.

Chromosomal Mutations - Changes to Chromosome Structure

Type	Definition	Picture
Deletion	Deletions involve the _____ of part of a chromosome	<p style="text-align: center;">Deletion</p> <p style="text-align: right;">(lost)</p>
Duplication	Duplications produce _____ of part of a chromosome	<p style="text-align: center;">1 (A B C D E F G H I) 2 (A B C D E F G H I) C D 3 (A B C D C D E F G H I)</p>
Inversion	Inversions _____ the direction of parts of chromosomes	<p style="text-align: center;">1 (A B C D E F G H I) 2 (A B C) F E D G H I 3 (A B C F E D G H I)</p>
Translocation	Translocations occur when part of a chromosome _____ and attaches to _____ chromosome.	<p style="text-align: center;">Translocation</p>

Changes to Chromosome Number

Karyotyping Computer Activity

Open Internet Explorer and go to the following website: http://www.biology.arizona.edu/Human_Bio/activities/karyotyping/karyotyping.html

Introduction - Read this section and answer the following questions.

1. This exercise is a simulation of human karyotyping using digital images of _____ from actual human genetic studies.
2. What does karyotyping analysis involve?
3. What does Giemsa Dye do?
4. What do the thinnest bands on a chromosome represent?
5. What three features of a chromosome are compared in a karyotype?

Karyotyping Activity - Patient Histories

- Click on Patient Histories
- Read the description for Patient A
- Click on 'Complete Patient A's Karyotype. Read the instructions.'
- Match up the chromosomes for Patient A, including the extra chromosome. Click on the number where you think the matching chromosome goes.

Read Interpreting the Karyotype and Making a Diagnosis

6. How many chromosomes in a normal human karyotype?
7. How many autosomes (non sex chromosomes) in a normal human karyotype?
8. How many sex chromosomes (X or Y) in a normal human karyotype?
9. What sex chromosomes would you find in a male?
10. What sex chromosomes would you find in a female?

11. What notation would you use to characterize a normal female karyotype?

Scroll down to Patient A's Karyotype

12. How many chromosomes are shown in Patient A's karyotype?

13. At which chromosome number is there a missing or extra chromosome?

14. Using the chart at the bottom of the page, how would you diagnose Patient A? What is their chromosome abnormality?

Click on Patient B - Match up the missing chromosomes.

15. How many chromosomes are shown in Patient B's karyotype?

16. At which chromosome number is there a missing or extra chromosome?

17. Using the chart at the bottom of the page, how would you diagnose Patient B? What is their chromosome abnormality?

Click on Patient C - Match up the missing chromosomes.

18. How many chromosomes are shown in Patient C's karyotype?

19. At which chromosome number is there a missing or extra chromosome?

20. Using the chart at the bottom of the page, how would you diagnose Patient C? What is their chromosomal abnormality?

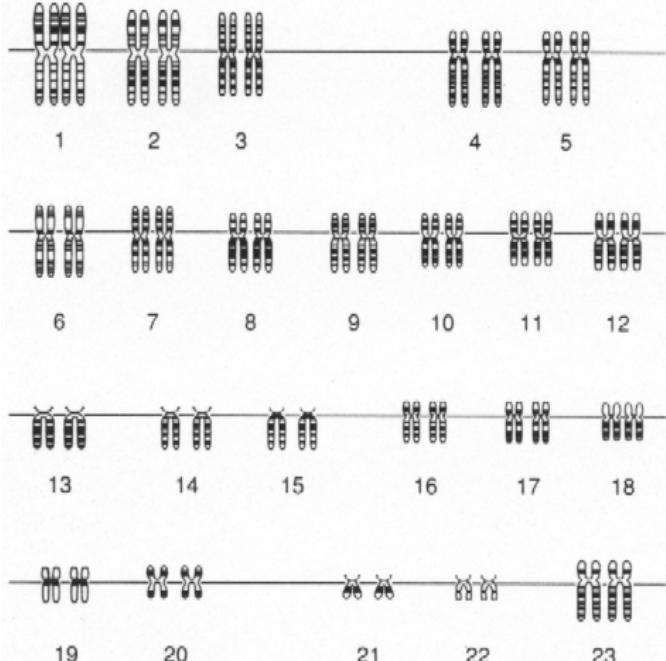
Identifying Genetic Disorders Using Karyotypes

Research the following genetic disorders to determine how their karyotype would look different from a normal karyotype.

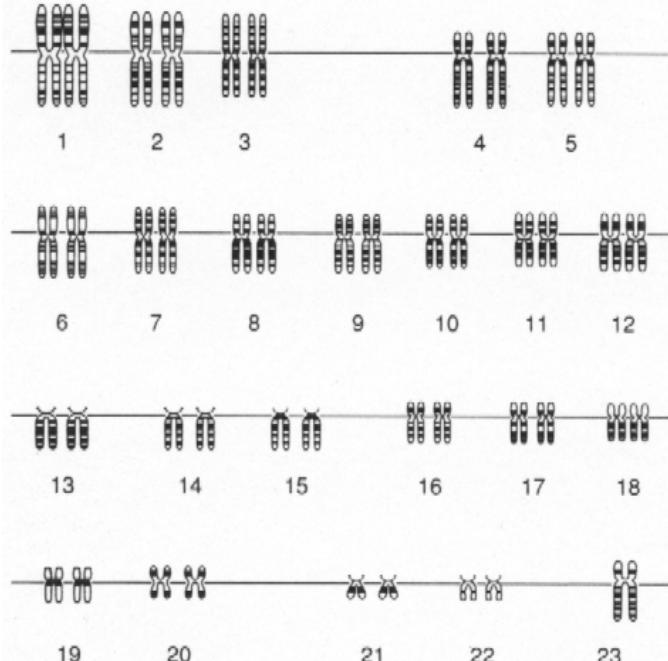
1. Down's Syndrome _____
2. Edward's Syndrome _____
3. Cri-du-Chat _____
4. Klinefelter's Syndrome _____
5. Jacob's Syndrome _____
6. Patau Syndrome _____
7. Turner's Syndrome _____

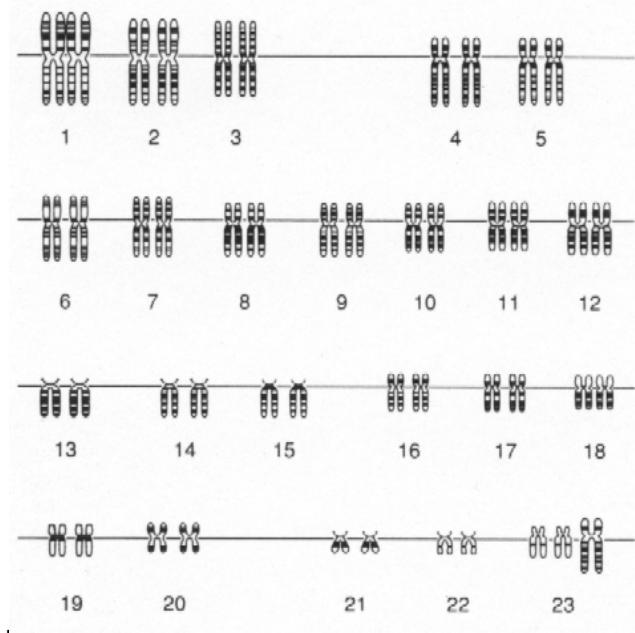
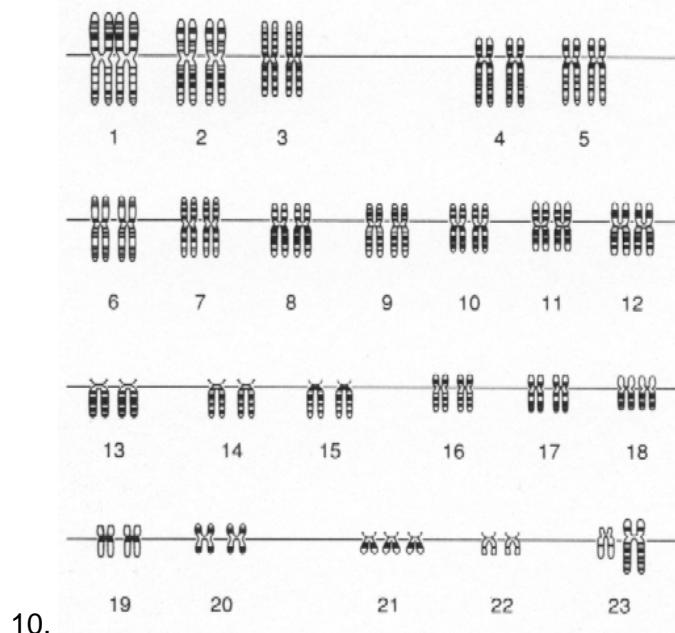
Use the information above to label the following karyotypes as one of the genetic disorders listed above, normal male, or normal female.

8.

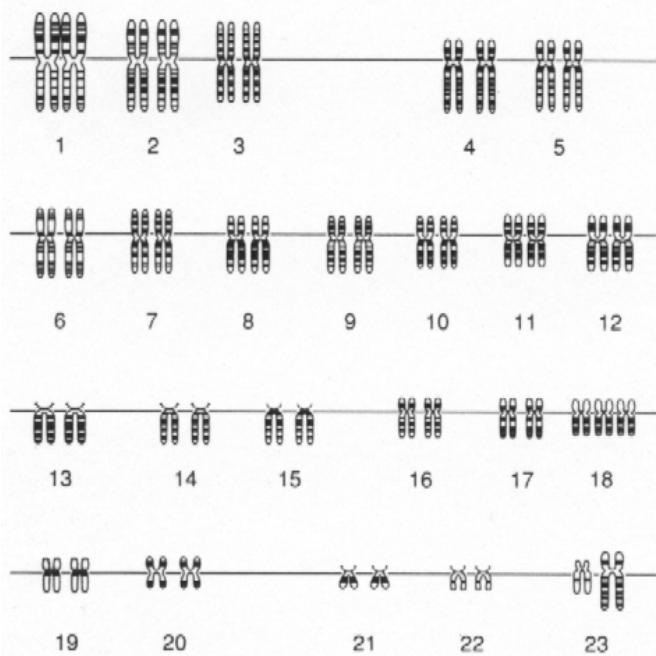


9.

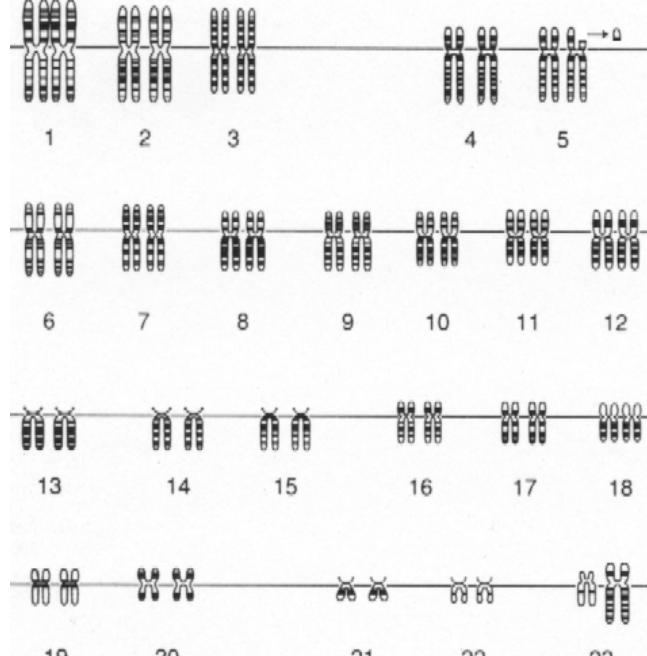


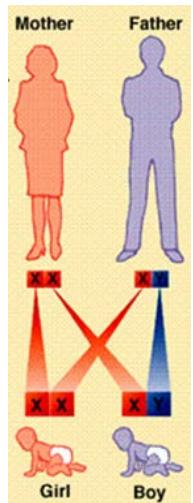


12.



13.

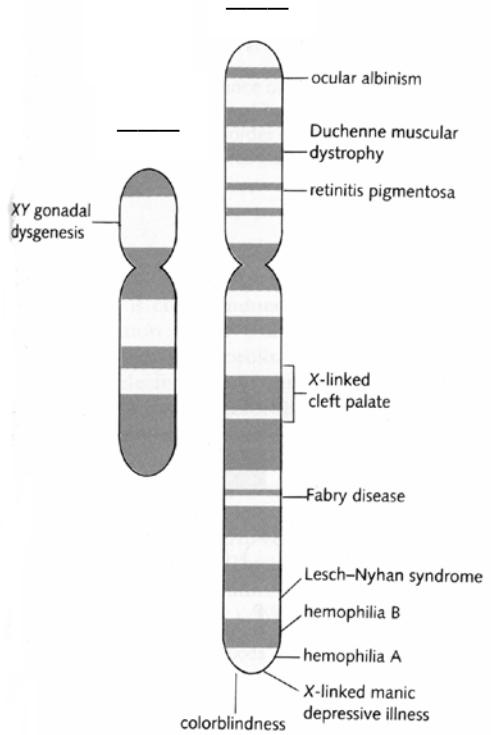
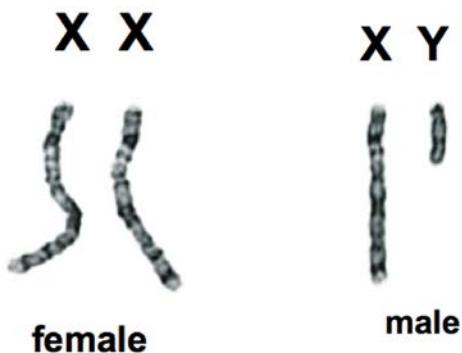


Notes: Sex-Linked Genes**Key Concept****Sex Determination in Humans**

- The 2 chromosomes that determine the sex of an individual are called the _____.
- The mother gives _____ of her offspring an _____ chromosome.
- The father gives _____ of his offspring the _____ chromosome and _____ the _____ chromosome.

Sex-Linked Genes & Traits

- Are inherited on the _____ or _____ chromosomes.
- Traits determined by sex-linked genes are called _____ traits.
- Most sex-linked genetic disorders are on the _____ chromosome.
- The _____ chromosome is much smaller than the _____ chromosome, and it contains _____ genes.



Males have _____ X chromosome. The allele that the male receives on his X chromosome is always expressed. <ul style="list-style-type: none"> • 1 normal X allele = normal • 1 affected X allele = affected 	$X^B Y$ = _____ male $X^b Y$ = _____ male
Females have _____ X chromosomes. Females receive two alleles. <ul style="list-style-type: none"> • 2 normal X alleles = normal • 1 normal X, 1 affected X allele = normal/cARRIER • 2 affected X alleles = affected 	$X^B X^B$ = _____ female $X^B X^b$ = _____ female(normal) $X^b X^b$ = _____ female

Cross a normal male with a carrier female. Draw the Punnett square. Label each individual as male/female and normal/carrier/affected .	Cross an affected male with a carrier female. Draw the Punnett square. Label each individual as male/female and normal/carrier/affected .
--	---

Examples of Sex-Linked Traits

- Colorblindness - 1 in 100 men
- Hemophilia - 1 in 10,000 men, lack the protein needed for normal blood clotting
- Muscular Dystrophy - 1 in 3000 men, progressive weakening and loss of muscles
- Baldness - 4 in 7 men, hair thinning or loss

****Sex linked traits are more common in men because men only need to inherit one copy of the recessive allele. Women must inherit two copies of the recessive allele to show the sex linked trait.****

Sex-Linked Genes Practice

1. In fruit flies, eye color is a sex-linked trait. Red eyes are dominant (R) to white eyes (r).

What are the sexes and eye colors of flies with the following genotypes:

$X^R X^r$ _____ $X^R Y$ _____

$X^r X^r$ _____ $X^r Y$ _____

2. What are the genotypes of these flies:

white eyed, male _____ red eyed female (heterozygous) _____

white eyed, female _____ red eyed, male _____

3. A white-eyed female $X^r X^r$ is crossed with a red-eyed male $X^R Y$. Draw the Punnett square.

What is the probability the offspring are:

red-eyed males _____ white-eyed males _____

red-eyed females _____ white-eyed females _____

4. A pure red-eyed female is crossed with a white-eyed male. Draw the Punnett square.

What are the genotypes of the parents? _____ x _____

What is the probability the offspring are:

red-eyed males _____ white-eyed males _____

red-eyed females _____ white-eyed females _____

5. Colorblindness is a sex-linked trait in humans. Normal vision is dominant (B); color blindness is recessive (b). A homozygous woman with normal vision is crossed with a colorblind man. Show the Punnett square. What are the genotypes of the parents? _____ x _____

What are the sexes and phenotypes of the offspring?

6. Cross a woman who is colorblind with a man with normal vision. Show the Punnett Square.
What are the genotypes of the parents? _____ x _____

What are the sexes and phenotypes of the offspring?

7. Duchenne Muscular Dystrophy is a sex-linked neurological disease. The normal allele is dominant (D), and the allele for the disease is recessive (d). Write the genotypes of the following:

female, normal _____ female, carrier _____ female, Duchenne MD _____
male, normal _____ male, Duchenne MD _____

8. A female who carries the disease is crossed with a man who has the disease. Draw the Punnett square.

What are the genotypes of the parents? _____ x _____

What are the sexes and phenotypes of their offspring?
