MEIOSIS

NAME _____

DATE _____

Introduction to Meiosis

http://vcell.ndsu.nodak.edu/animations/meiosis/movie-flash.htm

Many organisms pass their genes to their offspring through _____ _____.

This begins when two gametes unite to form an embryo that is genetically _____ from the parent organisms.

Gametes are formed through a process called _____.

There are _____ cell division events during meiosis.

The first division, _____, results in two unique daughter cells that have half the amount of DNA as the parent germ-line cell.

The second division, _____, results in four unique haploid cells that only have one copy of each chromosome. These haploid cells are the gametes that could go on to produce an offspring through sexual reproduction.

Meiosis begins with _____. In this stage, the DNA condenses to form chromosomes.

The duplicated sister chromatids joined together at the _____.

Next, each pair of homologous chromosomes undergoes _____ to form a complex involving two pairs of sister chromatids.

Chromosomal material is exchanged between the two pairs of sister chromatids. This event is called recombination or more commonly, _____. After crossing over, the sister chromatids for each chromosome are no longer identical to one another. This is one of the reasons why no two siblings (aside from twins) are genetically identical.

There are several more key steps in prophase I. The nuclear membrane begins to break down. Then the two centrosomes migrate to opposite ends of the cell and microtubules appear. The microtubules then attach to the chromosomes.

The next phase of meiosis I is called _____. Here the synapsed chromosomes align at the equator of the cell. The chromosomes align randomly which results in different combinations each time meiosis occurs.

The next phase is _____. During this phase, homologous chromosomes separate and migrate to the two poles of the cell. Importantly, the sister chromatids remain attached at their centromeres.

The final steps of meiosis I are _____and _____. Here the cell divides into two daughter cells.

The first stage of meiosis II is _____. Again, chromosomes condense, the nuclear envelop breaks down, and the spindle apparatus forms. The major difference between prophase II and prophase I is the fact that the daughter cells have only one copy of each homologous chromosome. So, in prophase II, there is no synapsis of homologous chromosomes or crossing over.

In _____, the chromosomes align at the equator of the cell. Again, the alignment is random. Since the sister chromatids are no longer identical, there will be many different possible ways for these chromosomes to align.

In _____, the sister chromatids are pulled apart as the microtubules shorten.

In _____, the nuclear membrane reforms, and the cytoplasm is divided into the two haploid daughter cells. This division is called cytokinesis. Since meiosis II began with two cells, and each of those cells were split into two cells, we now have 4 unique haploid cells at the end of meiosis. These cells are gametes.

Two gametes, one from the father and one from the mother, may fuse to produce a diploid embryo. The resulting embryo then grows through many cycles of mitosis.

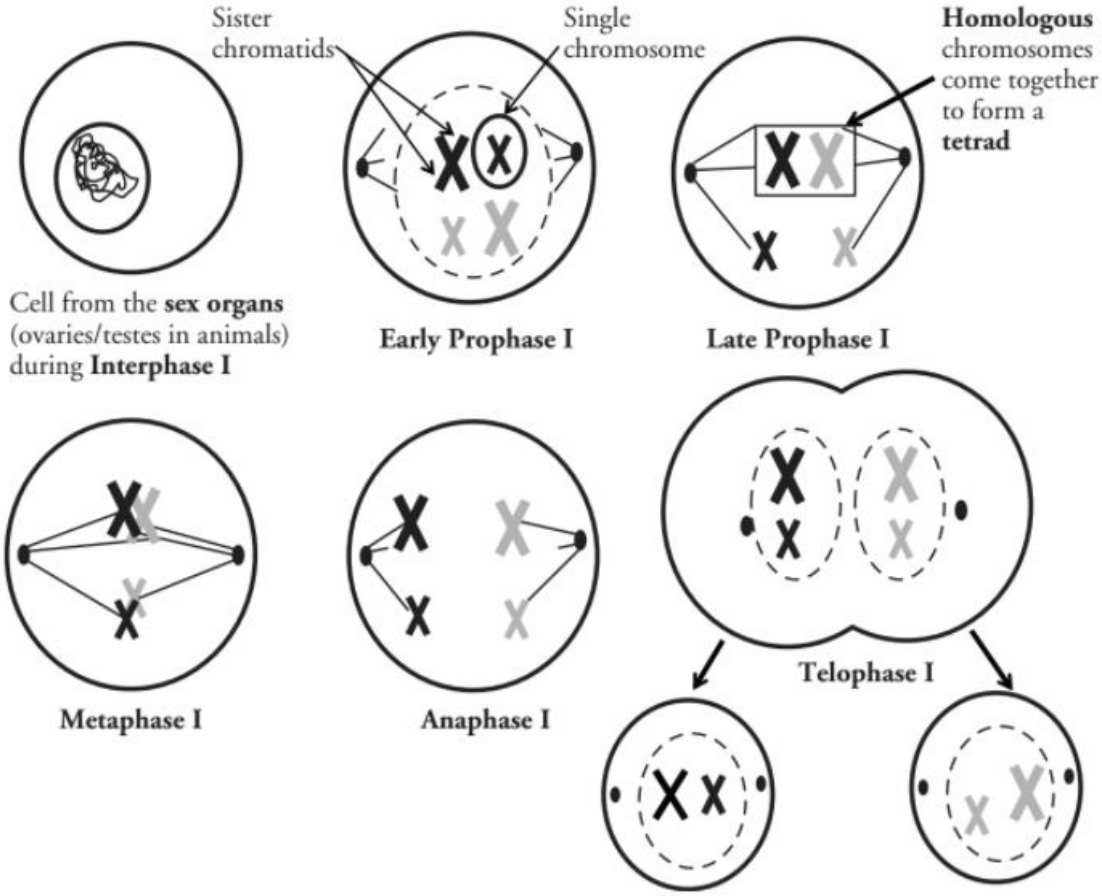
Meiosis

How does sexual reproduction lead to genetic variation?

Why?

Cells reproduce through mitosis to make exact copies of the original cell. This is done for growth and repair. Sexually-reproducing organisms have a second form of cell division that produces reproductive cells with half the number of chromosomes. This process is called **meiosis**, and without it, humans, oak trees, beetles, and all other sexually-reproducing organisms would be vastly different than they are today.

Model 1 – Meiosis I



1. According to Model 1, in what type of organs are the cells that enter meiosis I found?

2. Considering what you already know about mitosis in cells, what event must take place during interphase before a cell proceeds to division?

3. What two structures make up a single replicated chromosome?

4. In Model 1, how many replicated chromosomes does the cell contain during prophase?

Read This!

Alleles are alternative forms of the same gene. For example, gene A may contain the information for fur color. One allele "A" may result in white fur, while the alternative allele "a" may result in black fur. **Homologous chromosomes** are chromosomes that contain the same genes, although each chromosome in the homologous pair may have different alleles.

5. At which stage in meiosis I do the pairs of homologous chromosomes come together?

6. Once the chromosomes have formed a pair, what are they called?

7. At the end of meiosis I, two cells have been produced. How many replicated chromosomes are in each of these cells?

8. Cells with a full set of chromosomes are referred to as **diploid** or **2n**, whereas cells with half the chromosomes are **haploid** or **n**. At which stage(s) of meiosis I are the cells diploid and at which stage(s) are they haploid?

9. Which of the statements below correctly describes the relationship between the cells at the end of telophase I and the original cell?

   a. The new cells have one copy of all of the genetic information in the original cell.

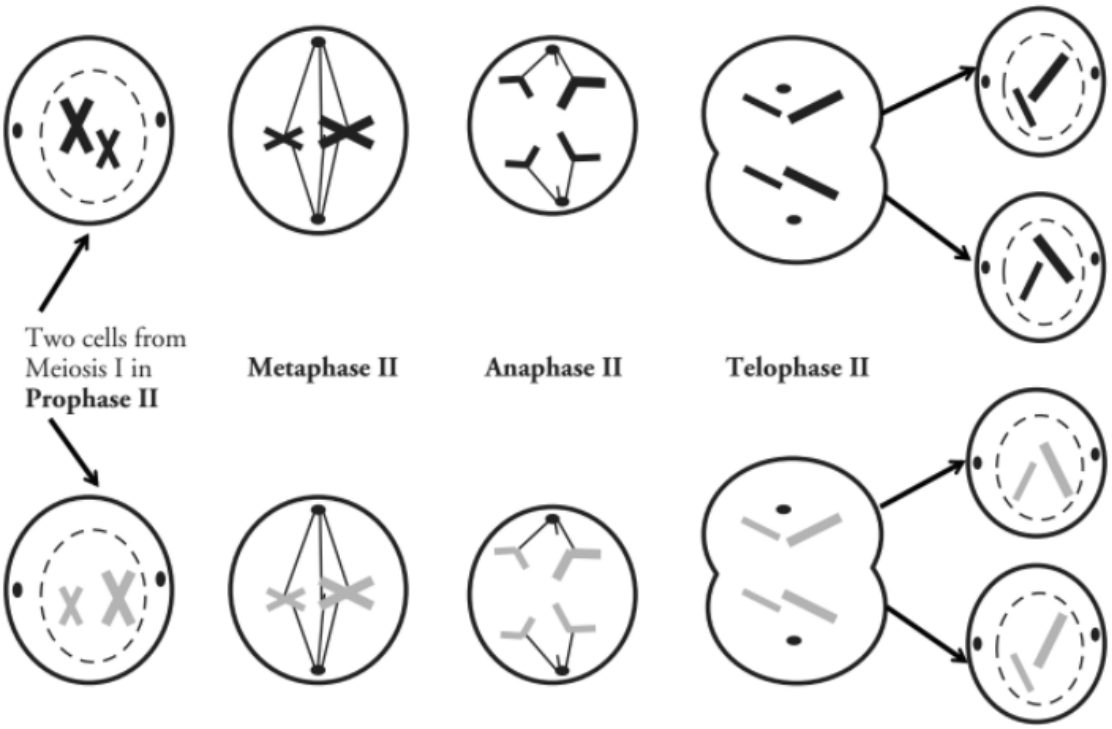
   b. The new cells have two copies of all of the genetic information in the original cell.

   c. The new cells have one copy of half of the genetic information in the original cell.

   d. The new cells have two copies of half of the genetic information in the original cell.

10. Considering the genetic makeup of the homologous pairs, will the cells at the end of telophase I be genetically identical to each other?

Model 2 – Meiosis II



11. According to Model 2, where did each of the cells come from that started meiosis II?

12. In meiosis I, during anaphase I, which structures separated—homologous chromosomes or sister chromatids?

13. In meiosis II, during anaphase II, which structures separated—homologous chromosomes or sister chromatids?

14. At the end of the meiosis II are four daughter cells. Are they haploid or diploid? Explain your answer in a complete sentence.

15. Which of the statements below correctly describes the relationship between the cells at the end of meiosis II and the original cell?

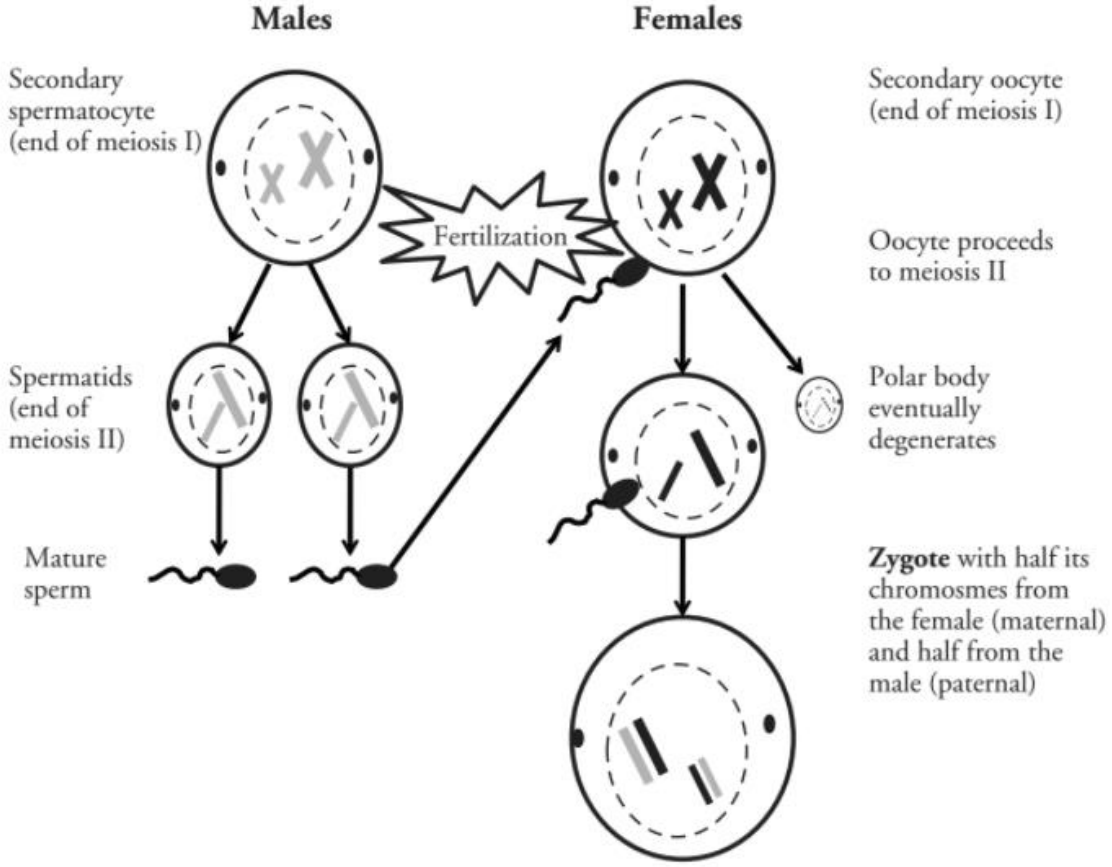
    a. The new cells have one copy of all of the genetic information in the original cell.

    b. The new cells have two copies of all of the genetic information in the original cell.

    c. The new cells have one copy of half of the genetic information in the original cell.

    d. The new cells have two copies of half of the genetic information in the original cell.

Model 3 – Gametogenesis and Fertilization (Human)



16. According to Model 3, what is the name given to the cells produced at the end of meiosis I in males?

17. What is the name given to the cells produced at the end of meiosis I in females?

18. Refer to Model 3.

    a. At the end of meiosis II in males, what cells are produced?

    b. What do these cells (from the previous question) eventually become?

19. Before fertilization, what happens to the secondary oocyte?

20. During fertilization which two cells come together? Be specific in your answer.

21. During meiosis II, the secondary oocyte divides unevenly, with one cell (the ovum) receiving half of the chromosomes and nearly all the cytoplasm and organelles, while the other cell, the polar body, is much smaller and eventually degenerates. With your group, propose an explanation to explain why the secondary oocyte divides in this way.

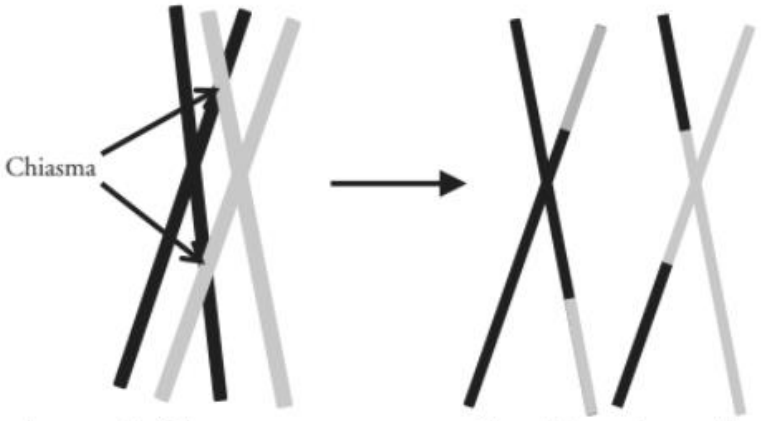
22. What is the **ploidy** of the zygote produced by fertilization—haploid or diploid?

23. What would the ploidy of the zygote be if egg and sperm were produced by mitosis rather than meiosis? How would this affect the ploidy of each successive generation?

24. With your group write a statement to explain the origin of the chromosomes found in the zygote. Your statement must include the term *homologous pair*.

Extension Questions

Model 4 – Crossover of DNA in Chromosomes



25. At which stage of meiosis are the chromosomes in Model 4?

26. When the chromosomes come together as homologous pairs, the arms of the sister chromatids may cross over.

    a. What are these crossover points called?

    b. Describe what happens to the chromatids during crossover.

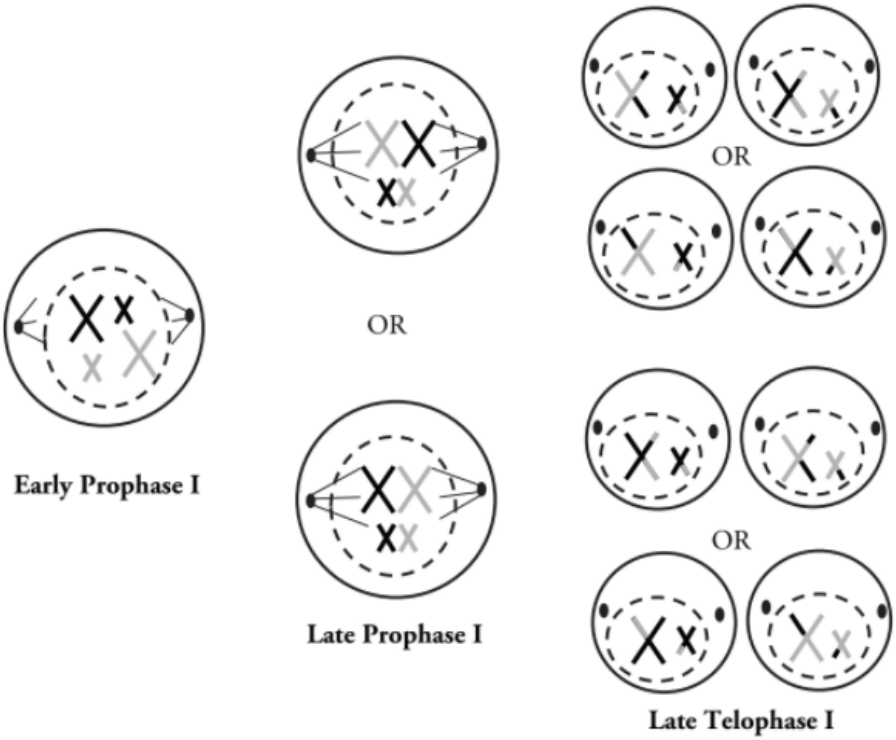
27. What phrase is used to describe the chromatids after crossing over takes place and the homologous chromosomes separate?

28. Compare the recombinant chromatids with the original pair.

    a. Are the genes on a recombinant chromatid the same as the original chromatid?

    b. Are the alleles on a recombinant chromatid the same as the original chromatid?

Model 5 – Genetic Variation



29. Model 5 is a condensed version of meiosis I. Notice the two possible arrangements of chromosomes in late prophase I. Considering what you know about DNA replication and meiosis, is either arrangement equally likely during the formation of tetrads in late prophase I? Explain.

30. If there were three sets of homologous chromosomes in the cell in Model 5, how many possible arrangements would there be for the tetrads in late prophase I?

Read This!

When homologous chromosome pairs align on the spindle during metaphase I the orientation of one pair is independent of the orientation of any other pair. This is known as **independent assortment**. Humans have 46 chromosomes, arranged as 23 pairs. During metaphase I each pair lines up independently, which results in 2^{23} **possible combinations.**

31. With your group, calculate the number of possible genetic combinations due to independent assortment.

32. As a group, choose one set of daughter cells in late telophase I from Model 5. Imagine that those cells now undergo meiosis II. Draw at least four resulting haploid cells that could result.

33. Meiosis and sexual reproduction each lead to variation in the genetic make-up of every person. With your group, explain how meiotic events, as well as the random fertilization of eggs and sperm, together lead to this genetic variation.

Chromosomes and Chromosome Number

All students in your class have characteristics passed on to them by their parents. Each characteristic, such as hair color, eye color, and height, is called a trait.

The instructions for each trait are found on chromosomes. Recall that chromosomes are found in the nuclei of cells. The DNA on the chromosomes is arranged in sections that control the production of proteins. These DNA sections are called **genes.** Each chromosome has about 1500 genes. Each gene has a role in the characteristics of the cell and how the cell works. Living things have thousands of genes.

Human body cells have 46 chromosomes. Chromosomes come in pairs. You have 23 chromosomes from your father and 23 chromosomes from your mother, making 23 pairs of chromosomes.

What are homologous chromosomes?

The chromosomes that make up a pair, one from each parent, are called **homologous** (huh MAH luh gus) **chromosomes**. Homologous chromosomes are the same length and have the centromere in the same place. They also carry genes for the same traits at the same place. Look at the picture below, and see if you can spot the homologous pair.

Homologous chromosomes are similar but not identical. For example, the gene for ear shape will be located at the same place on each homologous chromosome. Although these genes code for ear shape, the gene on one chromosome might code for one ear shape. The gene on the other chromosome might code for a different ear shape.

How is chromosome number maintained in a species?

The number of chromosomes does not change from generation to generation. You have the same number of chromosomes as your parents. **Gametes** (GA meets), or sex cells with half the number of chromosomes, ensure the chromosome number stays the same.

The symbol *n* represents the number of chromosomes. In humans, *n* is equal to 23. A cell with *n* number of chromosomes is called a **haploid** cell. Gametes are haploid cells. ☑

The process in which one haploid gamete joins with another haploid gamete is called **fertilization**. After fertilization, the cell has *2n* chromosomes—*n* chromosomes from the female parent plus *n* chromosomes from the male parent. A cell with *2n* chromosomes is called a **diploid** cell. Notice that *n* also represents the number of chromosome pairs in an organism.

Meiosis I

Recall that most cells are formed by mitosis. During mitosis the chromosome number stays the same. Because sex cells need half the number of chromosomes, a different process of cell division is needed. Gametes are formed during a process called meiosis. **Meiosis** is a kind of cell division that reduces the number of chromosomes by half through the separation of homologous chromosomes. Meiosis takes place in the reproductive organs of plants and animals. During meiosis, there are two cell divisions. They are called meiosis I and meiosis II.

What happens during interphase I?

Just as in mitosis, a cell goes through interphase before undergoing meiosis. A cell in interphase carries out a variety of metabolic functions, copies its DNA, and makes proteins.

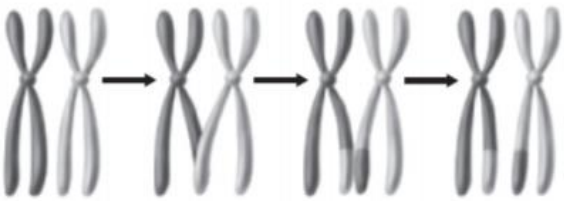
What happens during prophase I?

Meiosis I begins with prophase I. During prophase I, replicated chromosomes, consisting of two sister chromatids, condense. When that happens, the chromosomes become visible under a light microscope.

As the homologous chromosomes condense, they begin to form homologous pairs in a process called synapsis (suh NAP sus). The homologous chromosomes are held tightly together along their lengths by a protein that acts like a zipper. Prophase I continues as the chromosomes move to opposite sides of the cell.

What is crossing over?

During synapsis, the chromosomes often swap pieces of DNA. **Crossing over** occurs when a section of one chromosome changes place with a section of its homologous chromosome. This is shown in the figure below. The centrioles move to the opposite poles of the cell. Spindle fibers form and bind to the sister chromatids at the centromere.



What happens during metaphase I?

The next phase is metaphase I. During metaphase I, the pairs of homologous chromosomes line up in the center of the cell. The spindle fibers attach to the centromere of each homologous chromosome.

What happens during anaphase I?

Next is anaphase I. During anaphase I, each homologous chromosome is guided by the spindle fibers toward opposite poles of the cell. When this happens, the chromosome number is reduced from $2n$ to n. Notice that the sister chromatids do not split during meiosis I. Each homologous chromosome still has two sister chromatids. ☑

What is the final stage of meiosis I?

The final stage of meiosis I is telophase I. During telophase I, the homologous chromosomes reach opposite poles of the cell. Each pole contains only one member of a pair of homologous chromosomes.

The sister chromatids might not be identical because crossing over might have occurred during synapsis in prophase I. Crossing over is one way that meiosis leads to more genetic diversity. This diversity helps explain how species can change over time.

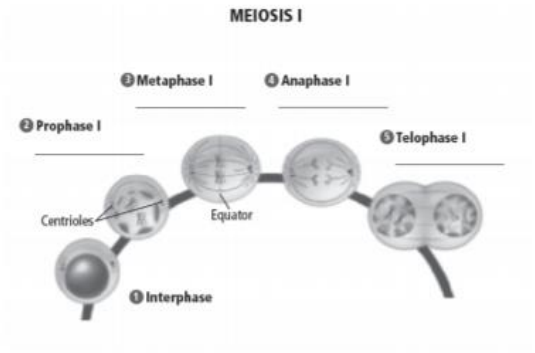
At the end of telophase I, the cell undergoes cytokinesis, meaning it divides into two cells. The cells then might go into interphase again, but this time, the DNA is not copied during interphase. The events of meiosis I are shown below.

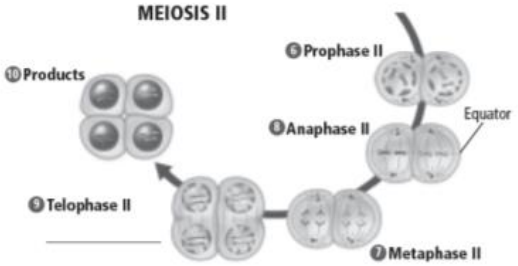
Meiosis II

Meiosis is now half finished. To complete meiosis, the cell must go through meiosis II. Meiosis II is similar to mitosis.

What events occur during meiosis II?

During prophase II, the spindle apparatus forms, and the chromosomes condense. During metaphase II, a haploid number of chromosomes lines up near the center of the cell by the spindle fibers. During anaphase II, the sister chromatids are pulled apart at the centromere by the spindle fibers, and the sister chromatids are pulled to the opposite poles of the cell. In telophase II, the chromosomes reach the poles, and the nuclear membrane and nuclei reform. Cytokinesis, or cell division, occurs. The result is four haploid cells, each with n number of chromosomes.





The Importance of Meiosis

The figure below shows that meiosis and mitosis have similar steps, but they are different in important ways. An important difference is that mitosis produces two identical diploid daughter cells, while meiosis produces four different haploid daughter cells.

	Mitosis	Meiosis
Number of cell divisions	one	two
Synapsis of homologous chromosomes	does not occur	occurs during prophase I
Products	_____ identical, diploid cells	_____ nonidentical, haploid cells
Type of cells produced	body cells	reproductive cells
Purpose	growth and repair of body tissues	production of gametes for sexual reproduction

Word Bank

Diploid
Gamete
Gene
Haploid
Homologous chromosomes
Meiosis
Fertilization
Crossing over

Use the terms in the left margin to complete the paragraph below.

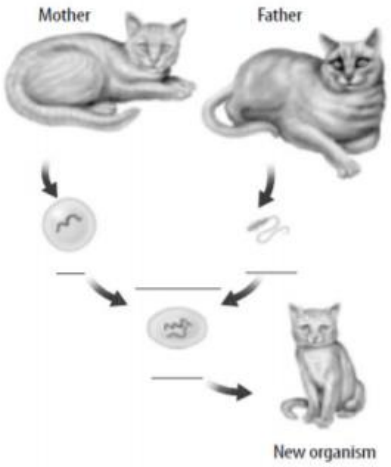
A segment of DNA on a chromosome that controls the production of a protein is called a _____. A _____ cell contains two copies of each chromosome. A sex cell, or _____, is _____, meaning it contains one copy of each chromosome. _____ are pairs of chromosomes, one from each parent.

Compare *meiosis and mitosis by filling in the chart below.*

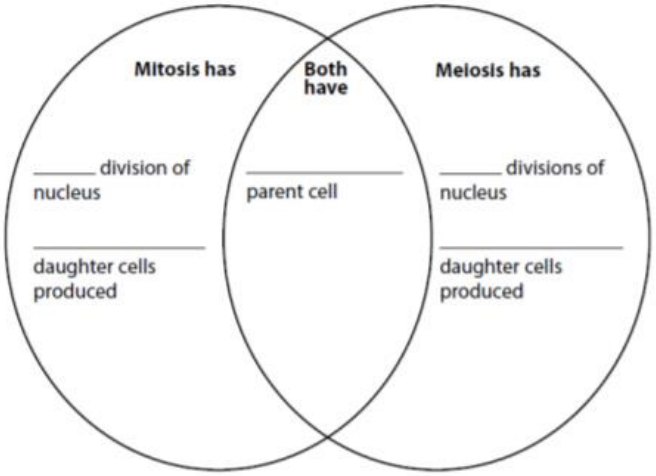
	Mitosis	Meiosis
Number of DNA replications		
Number of cell divisions		
Number of daughter cells		
Chromosome number of daughter cells		

Model *the process of* sexual reproduction. *Complete the diagram using these labels:*

- egg
- sperm
- fertilization
- zygote



Compare and contrast meiosis *and* mitosis *and cell division.*



Sexual Reproduction and Meiosis

Key Concept What is the order of the phases of meiosis, and what happens in each phase?

Directions: *On each line, write the term from the word bank that correctly completes each sentence. Some terms may be used more than once or not at all.*

diploid	**haploid**	**homologous chromosomes**
meiosis	**mitosis**	**sister chromatids**

1. In meiosis, one _____ cell divides to make four _____ cells.
2. A _____ cell has half the chromosomes of a _____ cell.
3. A _____ cell has pairs of chromosomes.
4. Pairs of chromosomes that are not identical but have genes for the same trait arranged in the same order are _____.
5. Each pair of _____ has one chromosome from the mother and one chromosome from the father.
6. In _____, the two chromosomes are always identical.
7. During _____, two divisions of the nucleus and the cytoplasm occur.
8. When a cell duplicates one chromosome, two _____ are formed.
9. During interphase of mitosis and meiosis, two _____ are formed for each chromosome.
10. A reproductive cell goes through interphase before beginning _____ I, but not before _____ II.
11. Prophase I and Prophase II are stages in _____.

Directions: *Answer each question on the lines provided.*

1. If a male organism has 40 chromosomes in each body cell, how many chromosomes does a female of the same species have in each body cell? _____
2. How many homologous pairs of chromosomes does the male have? _____
3. How many chromosomes would be in a sperm cell and in an egg cell? _____
4. How many chromosomes would be in an offspring? _____
5. How many pairs of homologous chromosomes would be in an offspring? _____

Label the diagrams below. Use these choices:

anaphase I **anaphase II** **interphase** **metaphase I** **metaphase II**
prophase I **prophase II** **telophase I** **telophase II**

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

6. _____ 7. _____ 8. _____ 9. _____

Complete the table by checking the correct column(s) for each description.

Description	Mitosis	Meiosis
10. Involved in the production of gametes		
11. Involved in growth and repair		
12. Promotes genetic variation in organisms		
13. Consists of one nuclear division		
14. Produces daughter cells that are genetically identical		
15. Involves two sets of nuclear divisions		
16. Produces daughter cells that are not identical		
17. Involves the synapsis of homologous chromosomes		
18. Occurs during asexual reproduction		
19. Results in four haploid gametes		
20. Also called *reduction division*		

Meiosis Lab

Purpose

To understand what happens to the chromosome number during gamete formation and fertilization and to see how variations develop in the offspring.

Materials

- Three "cell" sheets of paper
- Chromosome models

Procedure

1. Locate "Cell Sheet #1". This sheet contains 2 cells. 1 cell labeled male and 1 cell labeled female.
2. The male has inherited 3 green chromosomes (1 long, 1 medium, 1 short) from his father and 3 white chromosomes (1 long, 1 medium, 1 short) from his mother. Place these 6 chromosomes in the male cell.
3. The female has inherited 3 red chromosomes (1 long, 1 medium, 1 short) from her father and 3 black chromosomes (1 long, 1 medium, 1 short) from her mother. Place these 6 chromosomes in the female cell.
4. As these cells prepare to divide, each chromosome duplicates itself. So, there are twice as many chromosomes now as in the original cells. Attach these additional chromosomes the original chromosomes with a bead.
5. The chromosome pairs of the same kind (same length, but not necessarily the same color) then line up on an imaginary center axis of the cell. **HAVE YOUR TEACHER CHECK YOUR CHROMOSOME ALIGNMENT.**
6. Locate "Cell Sheet #2". This sheet contains 4 cells. 2 labeled male and 2 labeled female. After the chromosomes from step 5 have separated to the poles there would be two daughter cells. Carry out the division and separation steps for each of the cells on "Cell Sheet #1" and transfer the chromosomes to "Cell Sheet #2".
7. Locate "Cell Sheet #3". This sheet contains 8 cells. 4 labeled male and 4 labeled female (4 are mature sperm cells and 4 are potential egg cells). The chromosomes on "Cell Sheet #2" again line up on an equator and then separate to the polar regions. Thus, from the original one female cell on "Cell Sheet #1", we get 4 potential egg cells! Remove the bead from each sister chromatid and move the individual chromatids to these last cells. **HAVE YOUR TEACHER CHECK YOUR "CELL SHEET #3", BUT DO NOT PUT YOUR CHROMOSOMES AWAY YET!**
8. You have created 4 egg cells and 4 sperm cells. Combine each egg cell with a sperm cell by taking the chromosomes out of the sperm cell and placing them into an egg cell. Do this for each of the 4 sperm cells, so you now have 4 fertilized egg cells. Copy the chart below onto your white board and fill in the columns with the size and color of each chromosome found in the fertilized egg cells.

Fertilized Egg Cell #1	Fertilized Egg Cell #2	Fertilized Egg Cell #3	Fertilized Egg Cell #4

Questions

Record your answers to the following questions on your white board.

1. How many chromosomes were place in each of the original parent cells?
2. How many chromosomes are now in each one of the final reproductive cells?
3. If question 1 referred to humans, what would this number be?
4. If question 2 referred to humans, what would this number be?
5. What do these many different combinations tell you about reproduction by meiosis?
6. What is one important function of meiosis, as related to chromosomes number?

Conclusion

On a sheet paper write a brief summary of the lab. Write a conclusion, which includes the answers to the questions above.

https://www.cellsalive.com/meiosis.htm

Scroll down and read "Events during meiosis"

Click "Start Animation" and complete wprksheet

CELLS alive! - Meiosis Phase Worksheet

(Match the picture to the phase & tell what's happening now.)

Diploid Cell ( ) _____

Prophase I ( ) _____

Metaphase I ( ) _____

Anaphase I ( ) _____

Telophase I ( ) _____

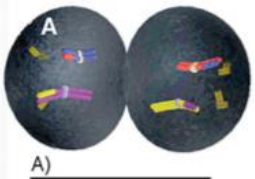
Prophase II ( ) _____

Metaphase II ( ) _____

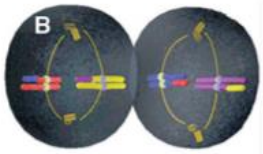
Anaphase II ( ) _____

Telophase II ( ) _____

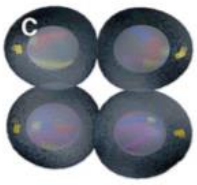
Gamete ( ) _____



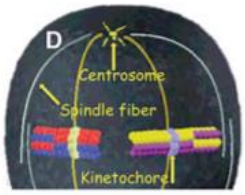
A) _____



B) _____

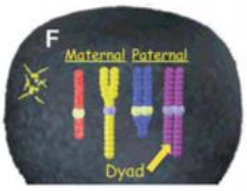


C) _____

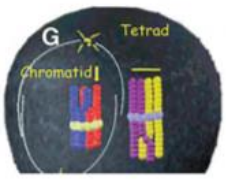


D) _____

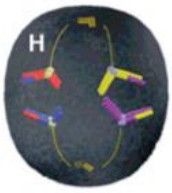
E) _____



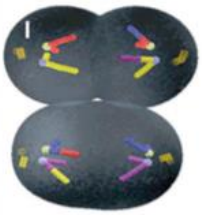
F) _____



G) _____



H) _____



I) _____

J) _____

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Reebop Meiosis

Problem:

To demonstrate how meiosis is responsible for the variation that exists in each species

Background Information:

"REEBOPS" are members of a new species developed by your crazed biology teacher, Miss Luckhardt. When investigated, a REEBOP was found to have 7 pairs or 14 total chromosomes in each of their somatic cells.

Materials:

14 red chromosomes representing mom

14 green chromosomes representing dad

Procedure:

1. Determine who will be mom and dad. Congratulations you will now become a new parent!!! :)
2. Turn your set of chromosomes face down on the desk so that the letters written on them are not visible.
3. Sort your chromosomes into homologous pairs.
4. Each person will take one of your chromosomes from each homologous pair and place them in the baby pile. You can return the other half of chromosomes to your envelope.
5. Your baby pile should consist of 7 red and 7 green chromosomes.
6. Sort the baby's chromosomes into homologous pairs. Each homologous pair should consist of 1 red and 1 green chromosome of the same length.
7. Decode the secret code of the characteristics for your REEBOP by referring to the key on the next page.

Take a picture of your Reebop

REEBOP DECODER KEY

Phenotype	Genotype	Key
1 Antenna	AA	Pipecleaner with bead
2 Antennas	Aa	Pipecleaners with beads
No Antenna	aa	Nothing
Curly Tail	TT, Tt	Pipecleaner
Straight Tail	tt	Pipecleaner
2 Body Segments	dd	Marshmellow
3 Body Segments	DD, Dd	Marshmellow
1 Green Hump	MM	Green Push Pin
2 Green Humps	Mm	Green Push Pins
3 Green Humps	mm	Green Push Pins
2 BlackEyes	EE, Ee	Black Map Tack
2 RedEyes	ee	Red Map Tack
Blue Nose	QQ	Blue Map Tack
Green Nose	Qq	Green Map Tack
Yellow Nose	qq	Yellow Map Tack
Red Legs	LL, Ll	Red Push Pins
Clear Legs	ll	Clear Push Pins

Questions:

1. What is a homologous pair?

2. What type of cell division is represented in this lab?

3. What is the haploid number for your REEBOP species?

4. What is the haploid number for your REEBOP species?

Observation Questions:

5. Are any 2 babies alike? If not, explain why not.

6. Name 3 traits that seem to be dominant among the babies.

7. If any of the babies were identical, what would you know about their chromosomes?

8. Are any baby "REEBOPS" missing some traits? Why do you think this might happen?

Analysis Questions:

9. How many letters are needed for each trait in the offspring REEBOPS?

10. What do these letters actually represent in nature?

11. Why did you select only one chromosome for each pair from each parent?

12. In what cells would these "half pairs" be found?

13. What type of cell division guarantees that only half the chromosomes are contributed by each parent?

14. Do you agree that meiosis contributes to variation in a species? Why or why not?

REVIEW OF MITOSIS AND MEIOSIS

https://www.youtube.com/watch?v=FODmSmG5z2Y

Take appropriate notes on this review video below:

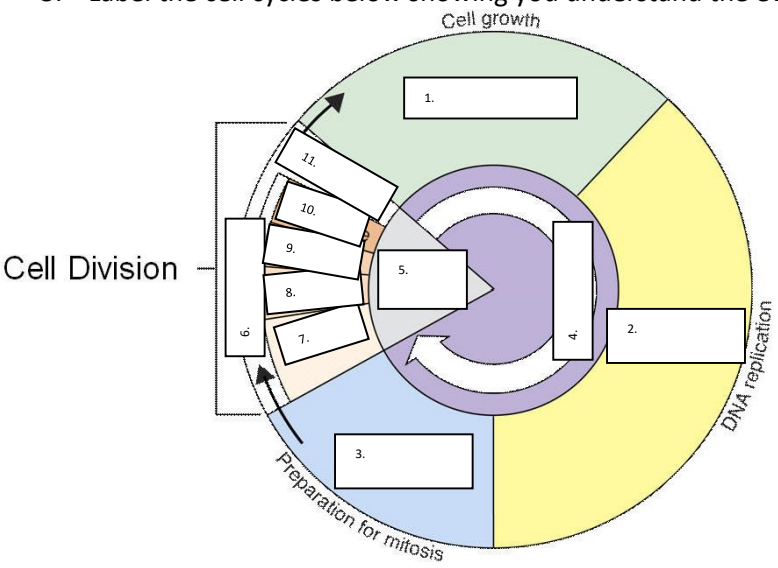
Review Sheet: Cell Cycle (Mitosis & Meiosis)

1. Why do cells divide?

2. Fill in the following tables showing you understand the two types of cell divisions:

What are the two types of cell divisions?		
What is the purpose of each type of cell division?		
How many and what type of cells are produced from each type of cell division?		

3. Label the cell cycles below showing you understand the events that occur in each.



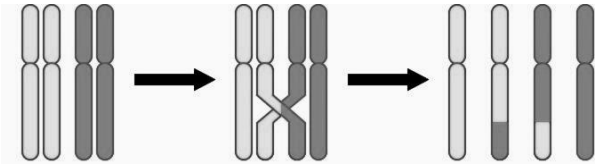
4. Cells spend most of their time in which part of the cell cycle? _____
5. What happens during the S-phase? _____
6. What happens during G_1 and G_2? _____
7. What happens in G_0? _____
8. G_1, S, and G_2 are collectively called? _____
9. What happens during the M-phase? _____
10. List in order, the phases of mitosis (M-phase) _____
11. After the M-phase, cells go through cytokinesis; what does this mean? _____
12. What occurs during DNA replication? _____
13. Why does this have to occur before the nuclear contents or chromosomes are divided in mitosis?

14. Why is the cell cycle important to the growth of organisms?

15. What is the purpose of the check points in the cell cycle?

16. When the cell cycle doesn't proceed as it should, uncontrolled cell division can occur and diseases, such as _____result.
17. What is the significance of meiosis to sexual reproduction? (In terms of chromosome number and in terms of variation)

18. What event is pictured below? _____When does it occur? - _____Why is it important? _____



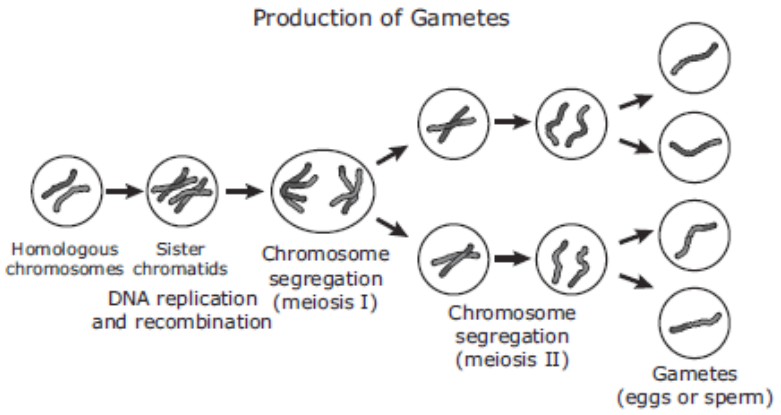
19. What is independent assortment? _____ (When does it occur? Why is it important? _____
20. A sudden genetic change is known as a(n) _____ and it can be (harmful, beneficial, or have no effect).
21. When homologous chromosomes fail to separate correctly during anaphase-I or if chromatids fail to separate correctly during anaphase-II, _____ occurs. An example of this could be _____
22. What is the significance of a mutation if it occurs in a somatic cell?

23. What is the significance of a mutation if it occurs in a germ cell or gamete?

24. After an egg is fertilized by a sperm cell, what is produced? _____ Is this cell diploid or haploid? _____ 2n or n? _____

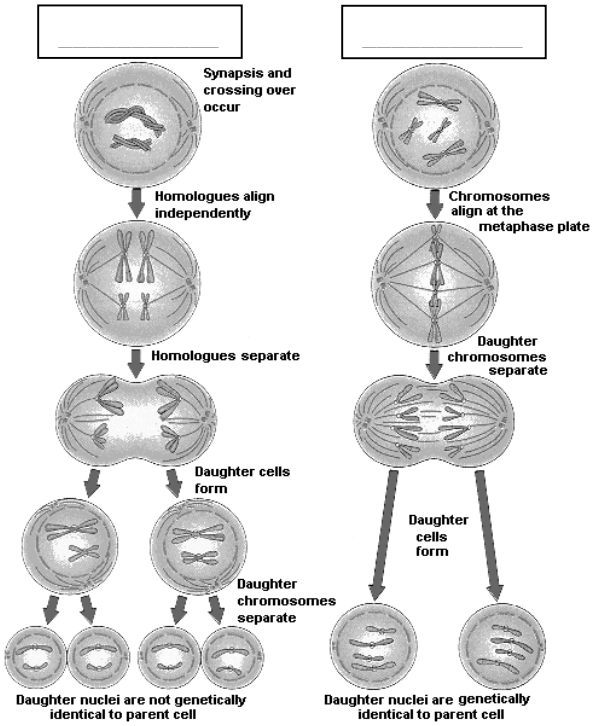
25. How is cytokinesis that follows mitosis different in a plant cell versus an animal cell?

26. Is the picture below mitosis or meiosis? _____ How can you tell?

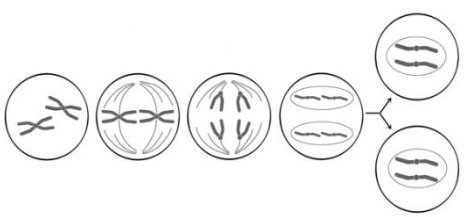


27. Fertilization of (n) gametes restores what chromosome number? _____

28. Identify which is mitosis and which is meiosis? How do you know you are correct?



29. Is this mitosis or meiosis? _____ How can you tell?



30. Check which type of cell division best describes the following? (You can check both if you need to)

	Mitosis	**Meiosis**
2n → 2n		
Produces identical daughter cells		
Diploid to haploid		
Produces gametes		
46 chromosomes → 23 chromosomes		
8 chromosomes → 8 chromosomes		
Replication occurs		