AP BIOLOGY NAME_____
EVOLUTION
Unit 1 Part 6 Chapter 13 DATE_____PERIOD_____
Activity #9

MEIOSIS LAB

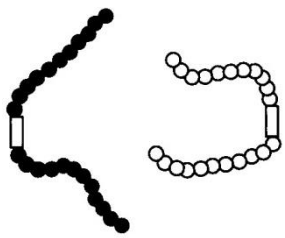
INTRODUCTION

Meiosis involves two successive nuclear divisions that produce four haploid cells. **Meiosis I** is the reduction division. It is this first division that reduces the chromosome number from diploid to haploid and separates the homologous pairs. **Meiosis II,** the second division, separates the sister chromatids. The result is four haploid gametes.

Mitotic cell division produces new cells genetically identical to the parent cell. Meiosis increases genetic variation in the population. Each diploid cell undergoing meiosis can produce 2^n different chromosomal combinations, where n is the haploid number. In humans the number is 2^{23}, which is more than eight million different combinations. Actually, the potential variation is even greater because, during meiosis I, each pair of chromosomes (homologous chromosomes) comes together in a process known as **synapsis.** Chromatids of homologous chromosomes may exchange parts in a process called **crossing over.** The relative distance between two genes on a given chromosome can be estimated by calculating the percentage of crossing over that takes place between them.

PART I: SIMULATION OF MEIOSIS

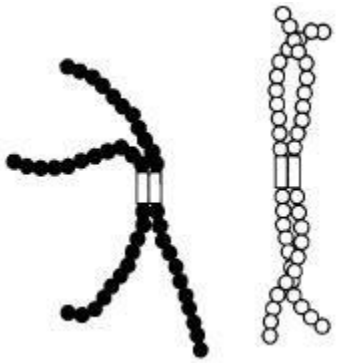
In this exercise you will study the process of meiosis using chromosome simulation kits. Your kit should contain two strands of beads of one color and two strands of another color. A homologous pair of chromosomes is represented by **one** strand of each color, with one of each pair coming from each parent. The second strands of each color are to be used as chromatids for each of these chromosomes.



Interphase:

Place one strand of each color near the center of your work area. (Recall that chromosomes at this stage would exist as diffuse chromatin and not as visible structures.) DNA synthesis occurs during interphase and each chromosome, originally composed of one strand, is now made up of two strands, or chromatids, joined together at the centromere region. Simulate DNA replication by bringing the magnetic centromere region of one strand in contact with the centromere region of the other of the same color. Do the same with its homolog.

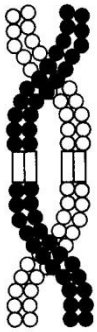
Summary: DNA Replication



Prophase I:

Homologous chromosomes come together and synapse along their entire length. **This pairing or synapsis of homologous chromosomes represents the first big difference between mitosis and meiosis.** A **tetrad,** consisting of four chromatids, is formed. Entwine the two chromosomes to simulate synapsis and the process of crossing over. Crossing over can be simulated by popping the beads apart on one chromatid, at the fifth bead or "gene," and doing the same with the other chromatid. Reconnect the beads to those of the other color. Proceed through prophase I of meiosis and note how crossing over results in recombination of genetic information.

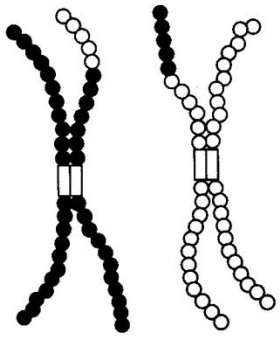
Summary: Synapsis and Crossing Over



Metaphase I:

The crossed-over tetrads line up in the center of the cell. Position the chromosomes near the middle of the cell.

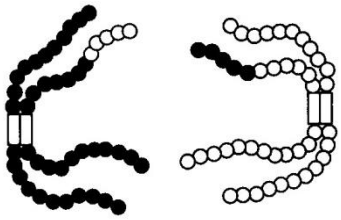
Summary: Tetrads align on equator



Anaphase I:

During anaphase I, the homologous chromosomes separate and are "pulled" to opposite sides of the cell. This represents a second significant difference between the events of mitosis and meiosis.

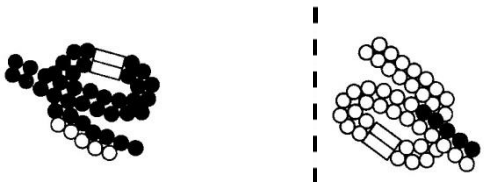
Summary: Tetrads separate
Chromosome number reduced



Telophase I:

Place each chromosome at opposite sides of the cell. Centriole duplication is completed in telophase in preparation for the next division. Formation of a nuclear envelope and division of the cytoplasm (cytokinesis) often occur at this time to produce two cells, but this is not always the case. Notice that each chromosome within the two daughter cells still consist of two chromatids.

Summary: 2 Haploid cells formed
Each chromosome composed of 2 chromatids



Meiosis II:

A second meiotic division is necessary to separate the chromatids of the chromosomes in the two daughter cells formed by this first division. This will reduce the amount of DNA to one strand per chromosome. This second division is called meiosis II. It resembles mitosis except that only one homolog from each homologous pair of chromosomes is present in each daughter cell undergoing meiosis II.

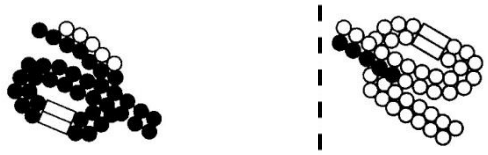
The following simulation procedures apply to haploid nuclei produced by meiosis 1.

Interphase II (Interkinesis):

The amount of time spent "at rest" following telophase I depends on the type of organism, the formation of new nuclear envelopes, and the degree of chromosomal uncoiling. Because interphase II does not necessarily resemble interphase I, it is often given a different name - interkinesis. DNA replication does not occur during interkinesis. This represents a third difference between mitosis and meiosis.

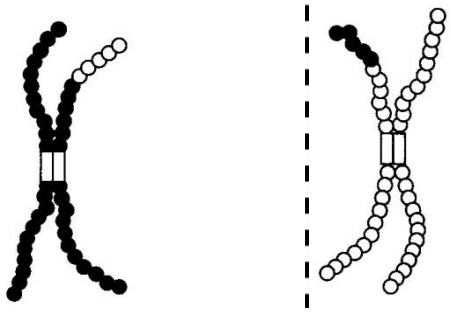
Prophase II:

No DNA replication occurs. Replicated centrioles (not shown) separate and move to opposite sides of the chromosome groups.



Metaphase II:

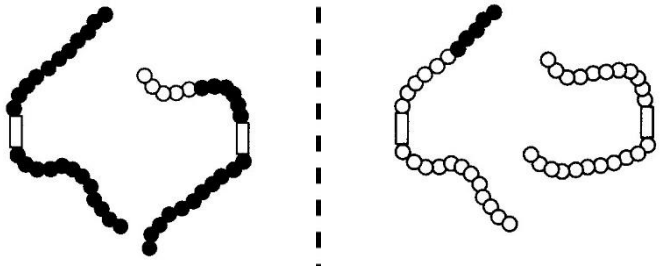
Orient the chromosomes so they are centered in the middle of each daughter cell.



Anaphase II:

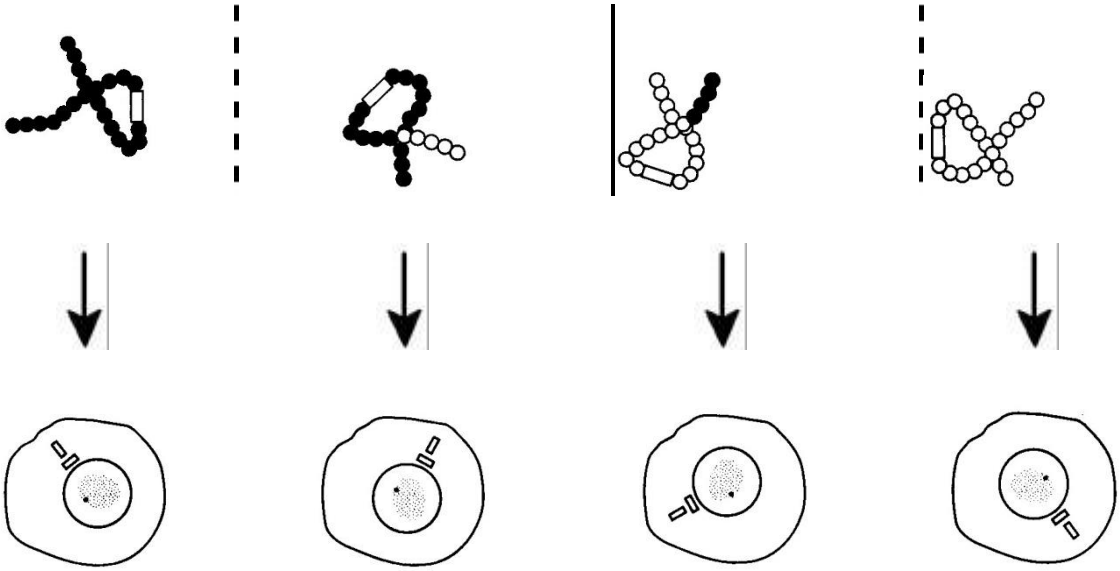
The centromere regions of the chromatids now appear to be separate. Separate the chromatids of the chromosomes and pull the daughter chromosomes toward the opposite sides of each daughter cell. Now that each chromatid has its own visibly separate centromere region, it can be called a chromosome.

Summary: Chromatids separate



Telophase II:

Place the chromosomes at opposite sides of the dividing cell. At this time a nuclear envelope forms and, in our simulation, the cytoplasm divides.



Analysis and Investigation:

1. Complete the following chart comparing mitosis and meiosis.

	Mitosis	**Meiosis**
Chromosome number in parent cells (2n or n)		
Number of DNA replications		
Number of divisions		
Number of daughter cells produced		
Chromosome number of daughter cells (2n or n)		
Purpose		

2. How are Meiosis I and Meiosis II different?

Meiosis I	**Meiosis II**

3. How do oogenesis and spermatogenesis differ? (meiosis In eggs and sperm)

Meiosis I	**Meiosis II**

4. Why is meiosis important for sexual reproduction?

_____

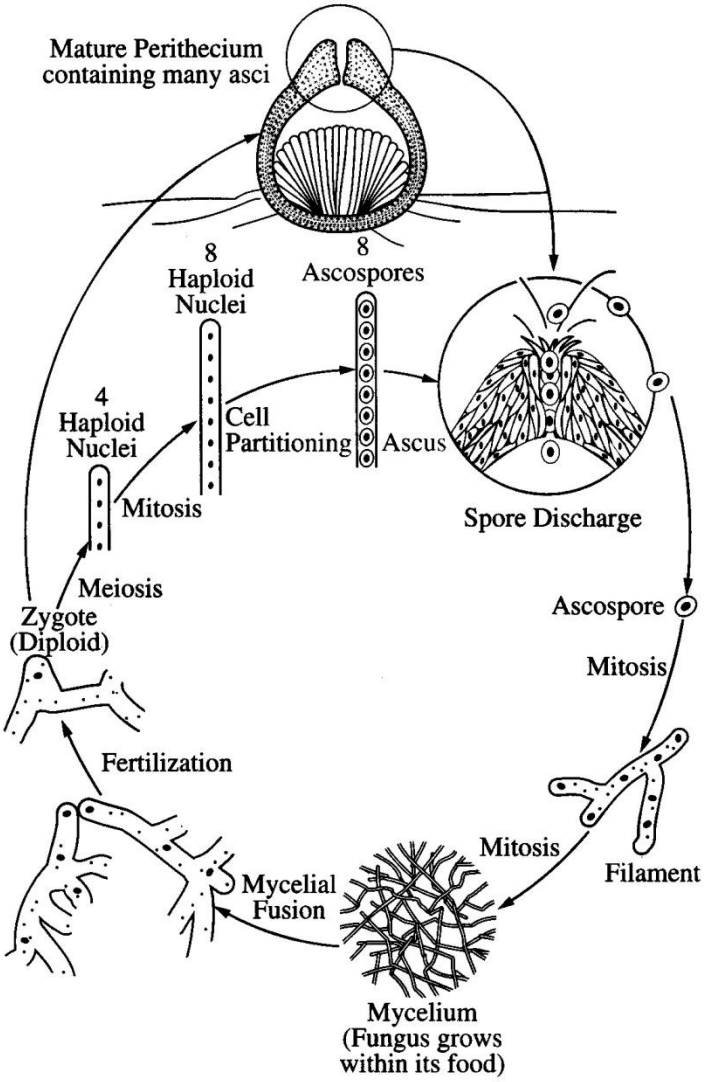
_____

_____

PART II: CROSSING OVER DURING MEIOSIS IN *SORDARIA*

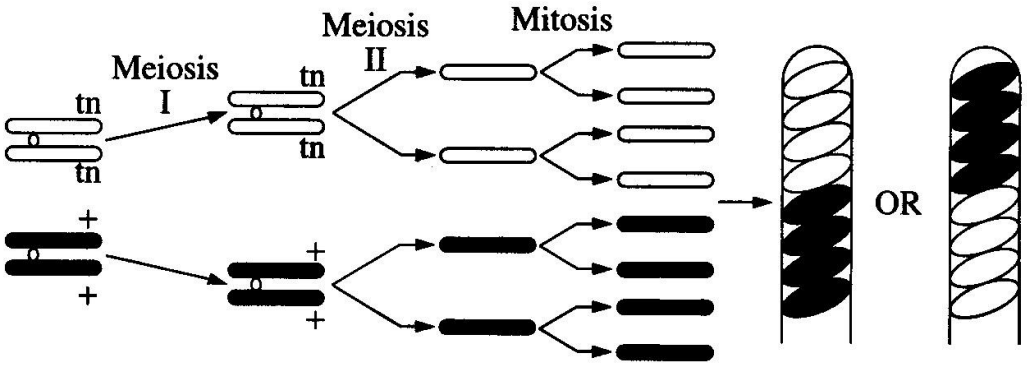
Sordaria fimicola is an ascomycete fungus that can be used to demonstrate the results of crossing over during meiosis. *Sordaria* is a **haploid** organism for most of its life cycle. It becomes **diploid** only when the fusion of the mycelia (filament-like groups of cells) of two different strains results in the fusion of the two different types of haploid nuclei to form a diploid nucleus. The diploid nucleus must then undergo meiosis to resume its haploid state.

Meiosis, followed by mitosis, in *Sordaria* results in the formation of eight **haploid ascospores** contained within a sac called an **ascus** (plural, **asci**). Many asci are contained within a fruiting body called a **perithecium.** When ascospores are mature the ascus ruptures, releasing the ascospores. Each ascospore can develop into a new haploid fungus. The life cycle *of Sordaria fimicola* is shown at the right.



To observe crossing over in *Sordaria,* one must make hybrids between wildtype and mutant strains of *Sordaria. Wild-type Sordaria* have black ascospores (+). One mutant strain has tan spores (tn). When mycelia of these two different strains come together and undergo meiosis, the asci that develop will contain four black ascospores and four tan ascospores. The arrangement of the spores directly reflects whether or not crossing over has occurred. In the diagram below, no crossing over has occurred.

FORMATION OF NONCROSSOVER ASCI



Two homologous chromosomes line up at metaphase I of meiosis. The two chromatids of one chromosome each carry the gene for tan spore color (tn) and the two chromatids of the other chromosome carry the gene for wild-type spore color (+).

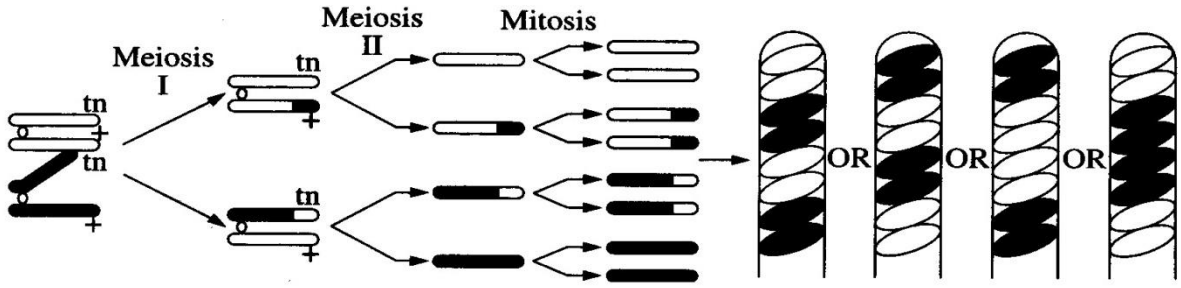
The first meiotic division (Meiosis I) results in two cells each containing just one type of spore color gene (either tan or wild-type). Therefore, segregation of these genes has occurred at the first meiotic division (Meiosis I).

The second meiotic division (Meiosis II) results in four cells, each with the haploid number of chromosomes (1n).

A **mitotic** division simply duplicates these cells, resulting in 8 spores. They are arranged in the 4:4 pattern.

The diagram below shows the results of crossing over between the centromere of the chromosome and the gene for ascospore color.

MEIOSIS WITH CROSSING OVER



In this example, crossing over has occurred in the region between the gene for spore color and the centromere. The homologous chromosomes separate during meiosis I.

This time, the Meiosis I results in two cells, each containing both genes (1 tan, 1 wild-type); therefore, the genes for spore color have not yet segregated.

Meiosis II results in segregation of the two types of genes for spore color. A **mitotic** division results in 8 spores arranged in the 2:2:2:2 or 2:4:2 pattern. Any one of these spore arrangements would indicate that crossing over has occurred between the gene for spore coat color and the centromere.

5. Examine each of the *Sordaria* pictures. For each picture, count the number of asci that do not show crossing over and the number showing crossing over.

Number of asci not showing crossing over ●●●●○○○○ ○○○○●●●●	Number of asci showing crossing over ○○●●○○●● ●●○○●●○○ ○○●●●●○○ ●●○○○○●●	**Total Asci**

The frequency of crossing over appears to be governed largely by the distance between genes, or in this case, between the gene for spore coat color and the centromere. The probability of a crossover occurring between two particular genes on the same chromosome (linked genes) increases as the distance between those

genes becomes larger. The frequency of crossover, therefore, appears to be directly proportional to the distance between genes.

A **map unit** is an arbitrary unit of measure used to describe relative distances between linked genes. The number of map units between two genes or between a gene and the centromere is equal to the percentage of recombinants. Customary units cannot be used because we cannot directly visualize genes with the light microscope. However, due to the relationship between distance and crossover frequency, we may use the map unit.

6. Using the data you collected in #1, determine the distance between the gene for spore color and the centromere. Calculate the percent of crossovers by dividing the number of crossover asci (2:2:2:2 or 2:4:2) by the total number of asci x 100%.

% of Crossovers = _____

7. To calculate the map distance, divide the percentage of crossover asci by 2. The percentage of crossover asci is divided by 2 because only half of the spores in each ascus are the result of a crossover event.

Map Distance = _____

8. Draw a pair of chromosomes in Meiosis I and Meiosis II, and show how you would get a 2:4:2 arrangement of ascospores by crossing over. Use the diagram on page 9 for help.

Part III: Questions

Note: Use pages 248 to complete these questions.

1. Match the term with the correct definition or description.

_____ Transmission of traits to offspring; Continuity of biological traits from one generation to the next	A. Variation
_____ Inherited differences among individuals within a species	B. Heredity
_____ Study of heredity and variation	C. Genetics

13.1

2. Describe the relationship among the following terms: **genes, DNA, chromosomes.**

_____

_____

_____

3. Determine if each of the following is true of **AS**exual or **S**exual reproduction.

_____ 1 parent
_____ 2 parents
_____ offspring gets all its genes from one parent
_____ offspring gets ½ of its from each parent
_____ offspring is a clone of the parent
_____ results in greater genetic variation
_____ offspring vary genetically from siblings and parent

13.2

4. Match the term with the correct definition.

a. Autosome	G. Karyotype
b. Diploid	H. Meiosis
c. Fertilization	I. Sex chromosome
d. Gamete	J. Somatic cell
e. Haploid	K. Zygote
f. Homologous chromosomes	

_____ Body cells; cells other than sex cells
_____ Display or photomicrograph of an individual's somatic-cell metaphase chromosomes arranged in standard sequence
_____ Pair of chromosomes that have the same size, centromere position and staining pattern
_____ A chromosome that is not a sex chromosome
_____ Dissimilar chromosomes that determine an individual's sex; X and Y
_____ Two sets of chromosomes; 2n
_____ One set of chromosomes; 1n
_____ Haploid reproductive cell; egg or sperm
_____ Cell division that produces haploid cells
_____ Fusion of egg and sperm; restores the diploid chromosome number
_____ Fertilized egg; diploid cell produced by the fusion of 2 haploid gametes

5. Classify each of the following characteristics as true of the **A**nimal, **F**ungi, or **P**lant sexual life cycle.

_____ gametes produced by meiosis
_____ gametes produced by mitosis
_____ gametes are the only haploid stage
_____ multicellular organism is diploid
_____ zygote is the only diploid stage
_____ multicellular organism is haploid
_____ alternation of generations
_____ multicellular haploid stage is called the gametophyte
_____ multicellular diploid stage is called the sporophyte
_____ spores produced by meiosis

6. What is a karyotype? _____

   a. How is it prepared? _____

   b. What three things can be determined with a karyotype?

      _____

      _____

      _____

7. What are *homologous chromosomes?* _____

   _____

8. Cells that have only one of each homologous pair are said to be *haploid*, a condition that is represented by *n*. Cells that have two of each homologous pair are said to be *diploid* or 2*n*. For each of the following, is the cell haploid or diploid?

Liver cell_____ gamete_____ egg_____
Zygote _____ skin cell_____ sperm_____
Somatic _____ Sex cell_____ heart cell_____

9. The muscle cells of a dog have 78 chromosomes. Fill in the correct chromosome number in a:

bone cell_____sperm_____ haploid cell_____ somatic cell_____ zygote_____

10. In the cell at right, the chromosomes are shaded in two colors to represent the parent of origin. On this sketch, label the following:

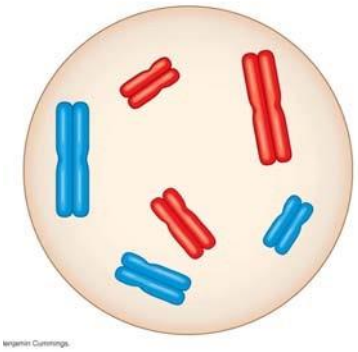
a. *sister chromatids*

b. *homologous chromosomes*

c. *centromere*

d. *replicated chromosome*

e. *maternal chromosomes*



11. How many chromosomes does the cell above have?

How many homologous pairs? _____

How many chromatids? _____

Is this cell haploid or diploid? _____

12. Where are the *gametes* of an animal produced? Be specific as to male and female gametes. _____

_____

_____

13. By what process are gametes produced? _____

14. What is another term for a fertilized egg? _____What is the chromosome number of the fertilized egg? (Answer this in general terms, haploid, *n*, or diploid, 2*n*.) _____

_____

_____

15. What is the purpose of *meiosis*? _____

_____

_____

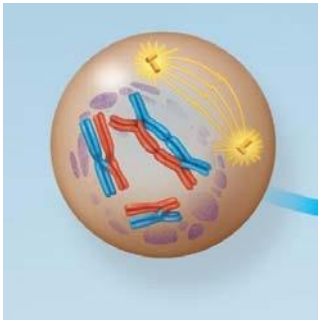
16. In meiosis, the DNA is replicated during interphase, followed by two divisions. The first division is meiosis I. Study the events of *prophase I* as they are significant. Explain each of these events:

synapsis

crossing over

chiasmata

PROPHASE I



17. The figure at the right shows metaphase I. How is the arrangement of chromosomes different from metaphase of mitosis?

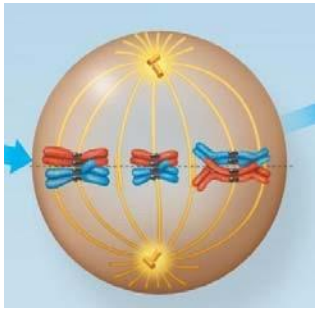
_____

_____

_____

_____

METAPHASE I

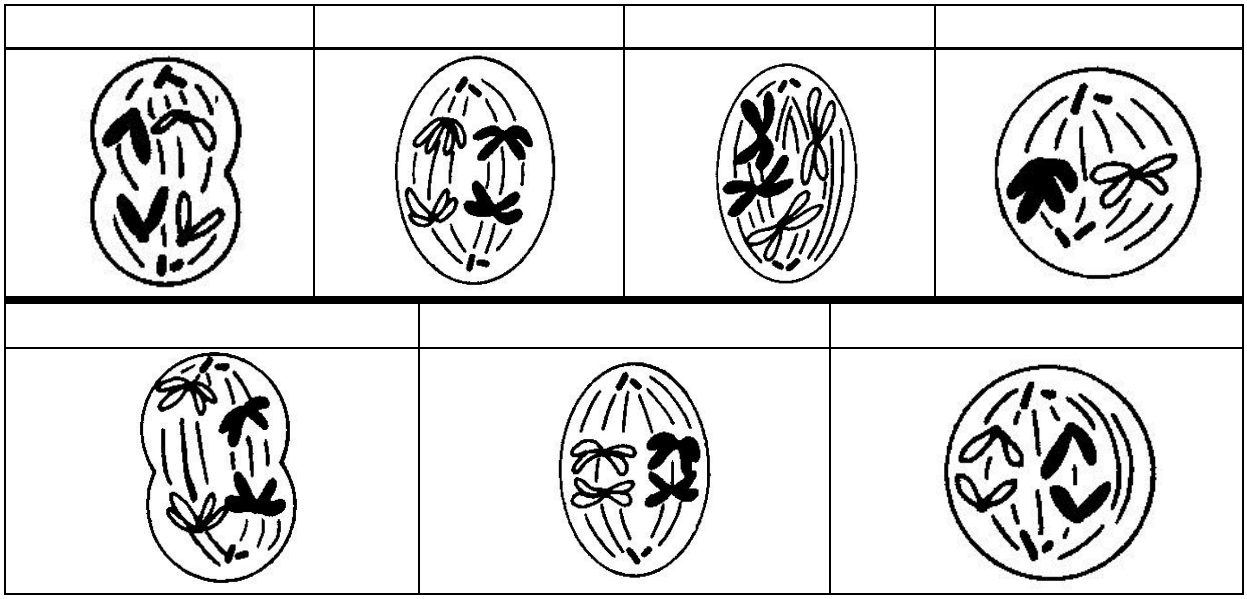


18. Match the characteristics with the correct phase.

A. Interphase I
B. Prophase I
C. Metaphase I
D. Anaphase I
E. Metaphase II
F. Anaphase II

_____ Centromeres split, sister chromatids separate; single stranded chromosomes pulled to opposite poles
_____ Chromosomes replicate
_____ Homologous chromosomes line up at the equator (metaphase plate)
_____ Chromosomes, consisting of two sister chromatids, line up singly at the metaphase plate
_____ Synapsis of homologous chromosomes; crossing over at chiasmata; spindle forms
_____ Homologous chromosomes separate and are pulled to opposite poles

19. Identify the phase of meiosis represented by each of the following diagrams.



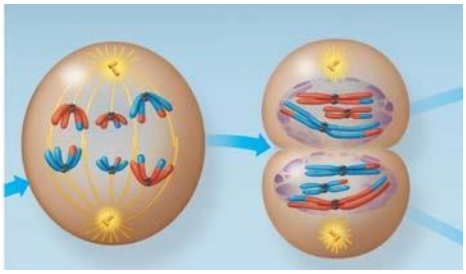
20. Classify each of the following characteristics as true of **MI**tosis or **ME**iosis.

_____ 1 division
_____ 2 divisions
_____ produces 2 daughter cells
_____ produces 4 daughter cells
_____ process used to produce gametes in animals
_____ maintains chromosome number
_____ cuts chromosome number in half
_____ produces cells that are clones of the mother cell
_____ creates genetic variation

19. There will be two divisions in meiosis. What will separate in the first division in meiosis I? _____
_____

20. Now study the chromosomes in *anaphase I* and *telophase I* carefully. How many chromosomes are in each cell at the end of the first meiotic division?
Anaphase: _____ Telphase: _____

Are the resultant daughter cells haploid, or diploid? _____



ANAPHASE I TELOPHASE I

**From this figure, you should see that chromosome number is reduced in meiosis I and that the daughter cells at the end of meiosis I are haploid. Remember this!

21. During meiosis I, homologous chromosomes separate. What separates during meiosis II? _____

_____

22. To check that you have the big picture, here are some quick review questions.
   a. What happens to chromosome number in meiosis?

   _____

   b. During which division is the chromosome number reduced?

   _____

   c. What is the purpose of meiosis?

   _____

   d. How many times does the cell divide in meiosis?

   _____

   e. How many times do the chromosomes duplicate?

   _____

   f. How many daughter cells are formed?

   _____

   g. What is the chromosome number?

   _____

   h. What are *homologs* (*homologous chromosomes*)?

   _____

i. What occurs in *synapsis*?

_____

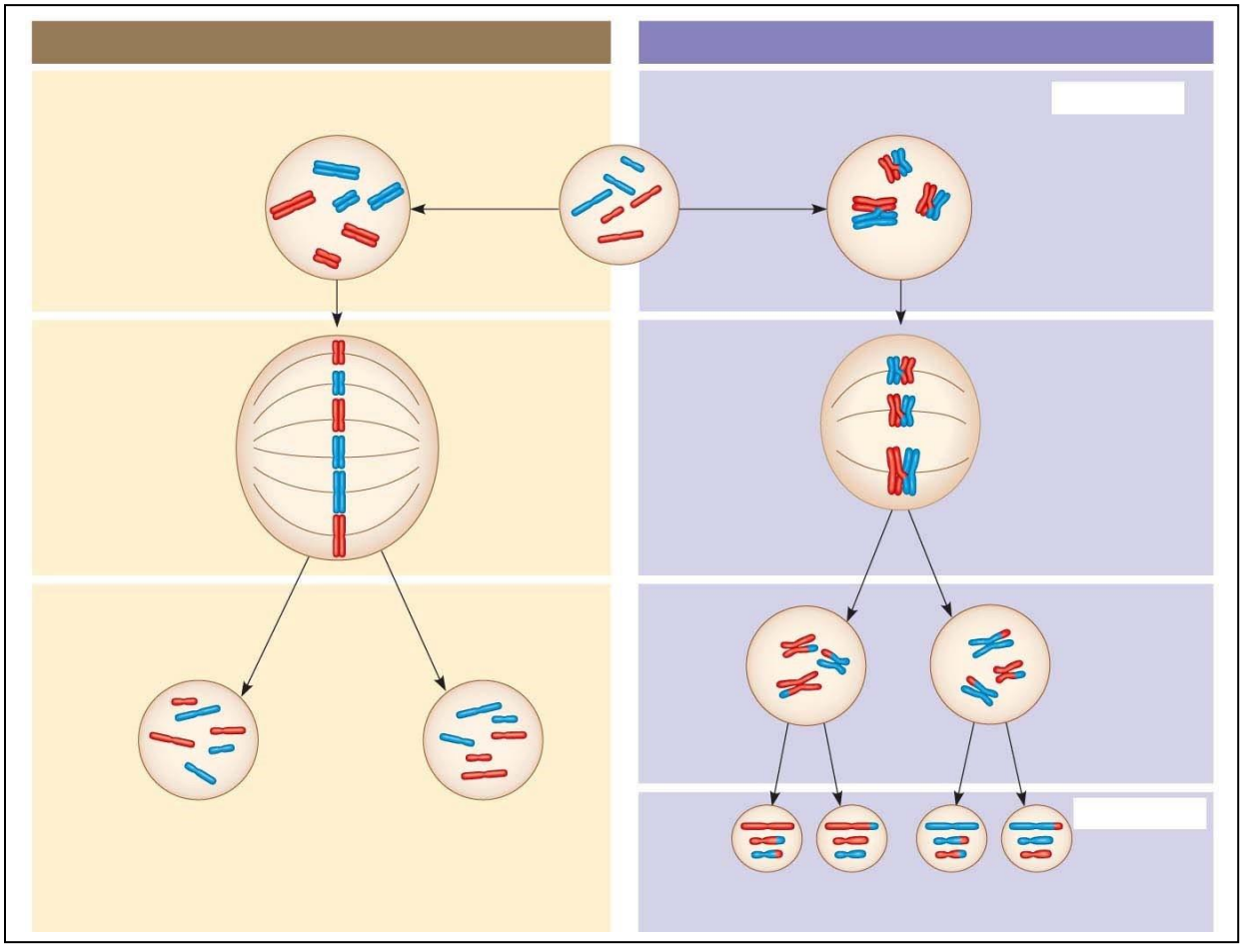
j. What is *crossing over*?

_____

23. Use Figure 13.9 to compare of mitosis and meiosis. Add these labels:

Parent cell, Mitosis, Meiosis, Synapsis, Homologous chromosomes, Replicated chromosomes, Sister chromatids, Daughter cells, Meiosis I, Meiosis II, Crossing over

As you label the drawing, carefully think about each process and review its important features.



28. Students often get confused about the differences between mitosis and meiosis. To help with this, work through the following chart:

	Mitosis	**Meiosis**
Role in the animal body		
Number of DNA replications		
Number of divisions		
Number of daughter cells		
Chromosome number of daughter cells		

13.4

21. Explain how each of the following is a source of genetic variation in a sexually reproducing population.

Independent Assortment	
Crossing Over	
Random Fertilization	

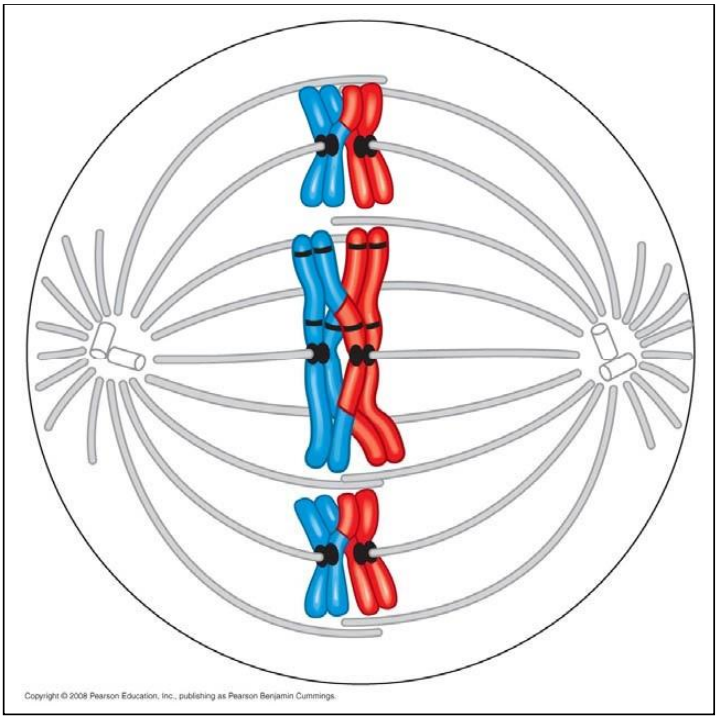
End of Chapter Synthesis and Evaluation Problems

Answer questions 1- 7, 10,12. Then, check and correct the answers to 1-7 in the back of the text.

1,_____
2._____
3._____
4._____
5._____
6._____
7._____

***Question 12 should be typed out, then answered in no more and no less tha 100 to 150 words. Turn in separately to the tray. This is worth **20 points!** Do not plagiarize Use your own words and thoughts…but, use vocabulary terms and ideas taught in this chapter!

9. Label the appropriate structures below with these terms, drawing lines or brackets as needed: chromosome (label as replicated or unreplicated), centromere, kinetochore, sister chromatids, nonsister chromatids, homologous pair, homologs, chiasma, sister chromatid cohesion.
   A. Describe the makeup of a haploid set and a diploid set_____
   _____
   _____
   B. Identify the stage of meiosis shown. _____



Study Guide/ISN (20 points)
In your study guide book, review pages 99 to 105 **AND** pages 304 to 306. In your ISN, title a page as follows: **Chapter 13 Meiosis Must Know!** In one color, copy down the must know items listed on page 99 **AND** page 304 in study guide leaving space underneath to include in an different color a brief description, diagram, model, or pneumonic device that will help you study for the unit test and more importantly the AP Test in May. Answer Questions 1-3 in Study guide. Correct your answers in back of SG text.
1._____ 2._____ 3._____

Bozeman/ AP Biology/ISN (See Syllabus for format) **(20 points each)**
1. Phases of Meiosis (Big Idea 3)
2. Sordaria Cross (Supplemental AP bio resources to)