STUDY GUIDE - *Ch. 13.3 - Meiosis Reduces the Number of Chromosomes Sets from Diploid to Haploid* **NAME:** _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

1. a. Return to Ch.12 & **review Figure 12.7 carefully.** How many **nuclear divisions** occur in **mitosis** during M phase?

   b. A cell that will undergo meiosis at the end of its cell cycle, just like one destined to undergo mitosis, must proceed through Interphase (G1, S, G2) first, before physically dividing in M phase. However, how many nuclear divisions take place in **meiosis** during M phase?

2. **Diploid organisms contain two sets of chromosomes**. Let's review some terminology learned earlier in Ch.12.1 & 13.2 What are the **difference between sister chromatids versus homologous chromosomes** (a.k.a. homologs). Review these definitions and *make sure you have them memorized before proceeding.*

   Sister Chromatids =

   Homologs *(Homologous Chromosomes)* **=**

3. a. Return to your Ch.**12.2** Study Guide, **WHEN in interphase of the cell cycle does a cell produce sister chromatids**?

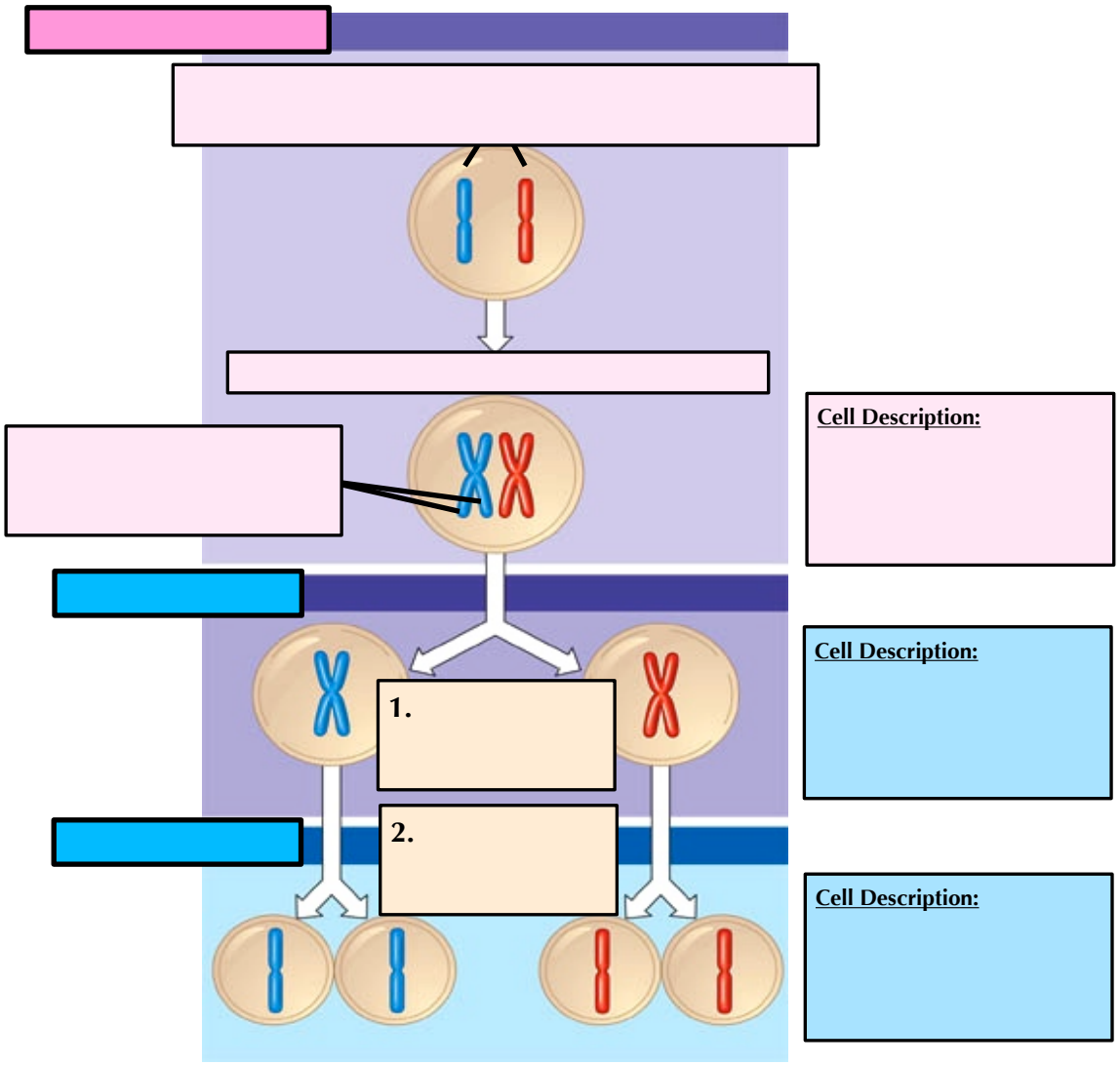
   b. Recalling from your Ch.**13.1&2** Study Guide, **HOW does a sexually reproducing organism get the homologous chromosomes it has**?

4. a. Homologous chromosomes are similar in that they are the same length of DNA, have genes for the same characteristics, and the centromere DNA sequence is found at the same location along the molecule's length (the location of a sequence of DNA on a chromosome is called its **locus**. Plural: **loci**). Instead of merely referring to the type of gene on a homolog (what characteristic that gene controls), we may also refer to the allele of that gene. What are **alleles**?

   b. Though not mentioned in the text yet and though you are **not** allowed to use the internet, only your textbook, when completing your study guides...let's make one excepting here. Look up some examples of alleles and describe an example you found of **2 different alleles for 1 type of gene**. *(No, you can't use the freckles example.)*

5. Let's review Figure 13.7. When in the cell cycle specifically is the DNA replicated in cells that will eventually undergo meiosis during M phase? *(Hint: it's the same as a cell that is destined to perform mitosis)*

6. **Memorize Figure 13.7 extremely well!** It is essential that you know this and can recall this quickly. Once you have studied it, test your memory by labeling the following diagram of meiosis (taking place during the Mitotic - M - Phase), starting with a cell in G1 of Interphase. ***Note that this starting cell is diploid (2n) with 2 chromosomes, 1 per set** (so... 2n = 2 since n = 1)*



7. From the figure above, you should see that **chromosome number is reduced in meiosis I** and that the **daughter cells at the end of meiosis I are haploid (n)**, though they still have **duplicated chromosomes**. *Remember this!*

   The daughter cells have **HALF the number of SETS** of chromosomes compared to the parent cell. So, a 2n cell produces cells that are n, but a 4n cell produces cells that are 2n, etc. *This is why meiosis is referred to as a **reduction division**, because we divide the cell and, thereby, reduce the number of **sets** of chromosomes in the daughter cells.*

   a. What separates during **meiosis I** that leads to the reduction in the number of sets (ploidy) of the cell?

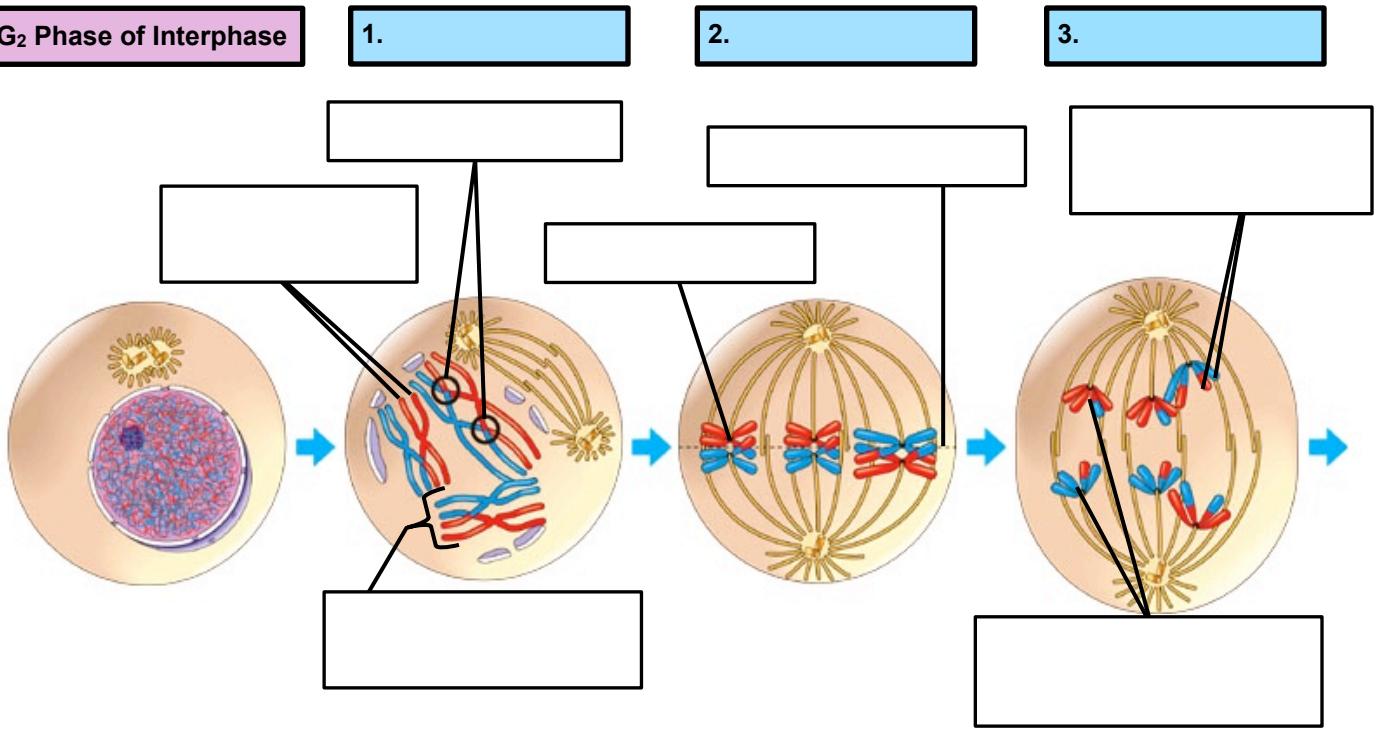
   b. What separates during **meiosis II**?

   c. Recall that mitosis does **NOT** reduce the number of sets of chromosomes in daughter cells relative to parent cells. **How many daughter cells** result from mitosis versus result from meiosis?

      # of daughter cells that form from **Mitosis** =

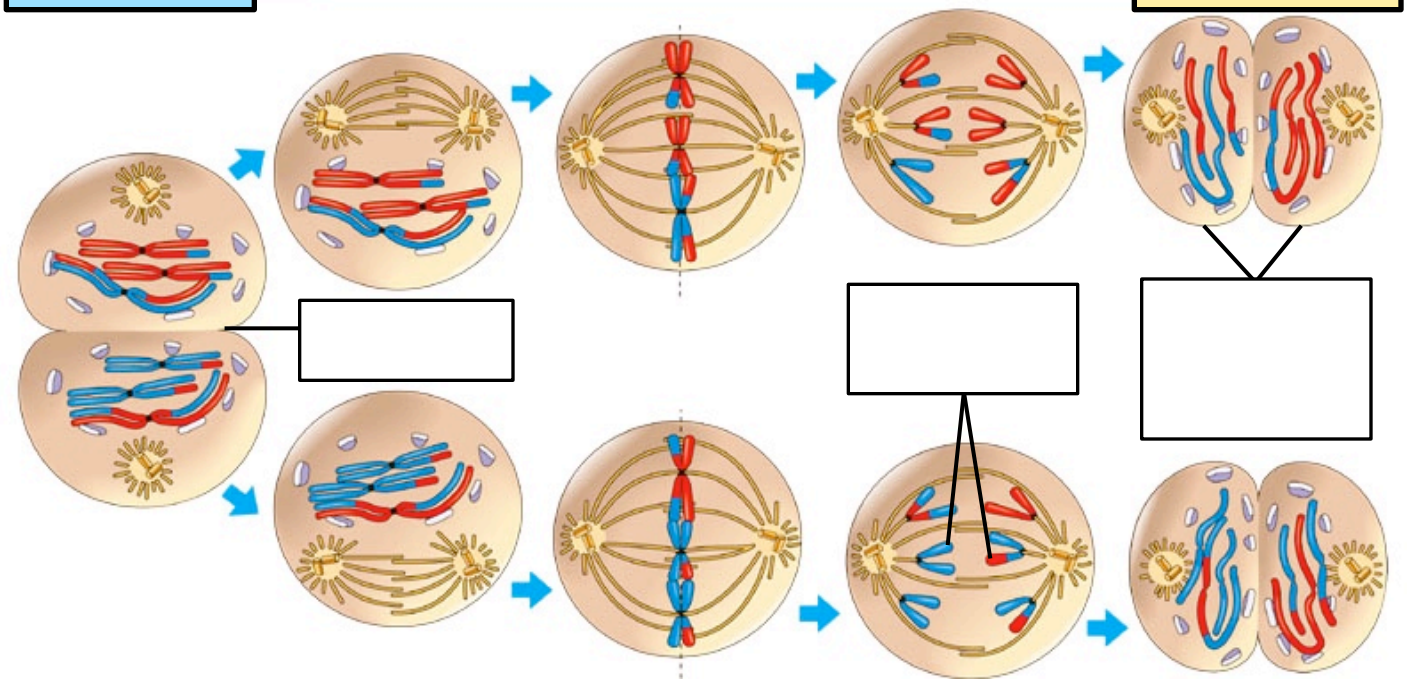
      # of daughter cells that form from **Meiosis** =

8. **Get to know all the steps of Meiosis by studying well Figure 13.8.** Then, test your knowledge of the events taking place in M phase, after the end of G2 of Interphase, by naming each stage of M phase, labeling the key structures visible in the cell during each phase, and **summarizing the key defining features and events** witnessed during that phase.



Key Feature & Events	Key Feature & Events	Key Feature & Events
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.		

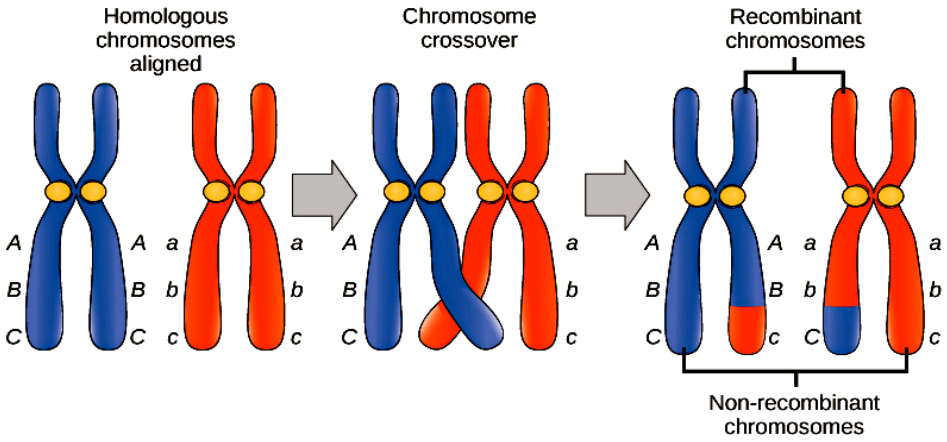
4.	5.	6	7.	8



Key Feature & Events	Key Feature & Events	Key Feature & Events	Key Feature & Events	Key Feature & Events
1.	1.	1.	1.	1.
2.	2.	2.		2.
3.		3.		3.
4.				
5.				

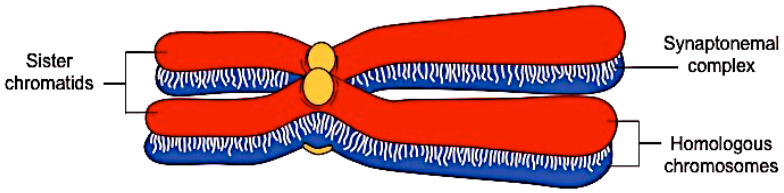
9. Review again Figure 13.8 & now **13.9**, while reading the corresponding text. The events taking place in **prophase I** of meiosis are significant and **generate some of the genetic diversity seen in daughter cells** that result from meiosis.

   a. Describe, out loud, in your own words, and then in writing, the four steps involved in crossing over, an important **Prophase I event**, outlined in the images below. As you describe the entire process, use the following terms: ***sister chromatids, cohesins, homologous chromosomes, gene alignment, synaptonemal complex, non-sister chromatids, synapsis, chiasmata.***



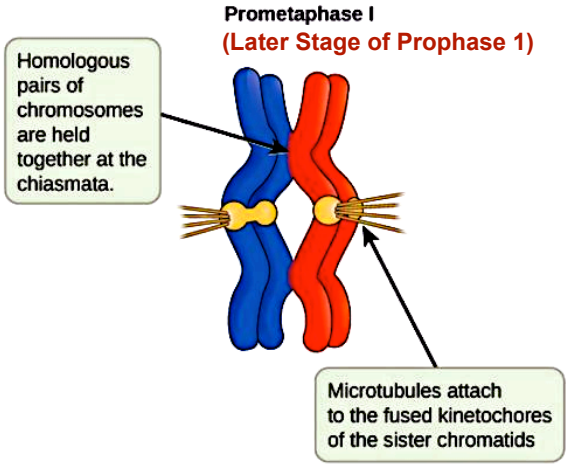
Step #1 =

Step #2 =



Step #3 =

Step #4 =



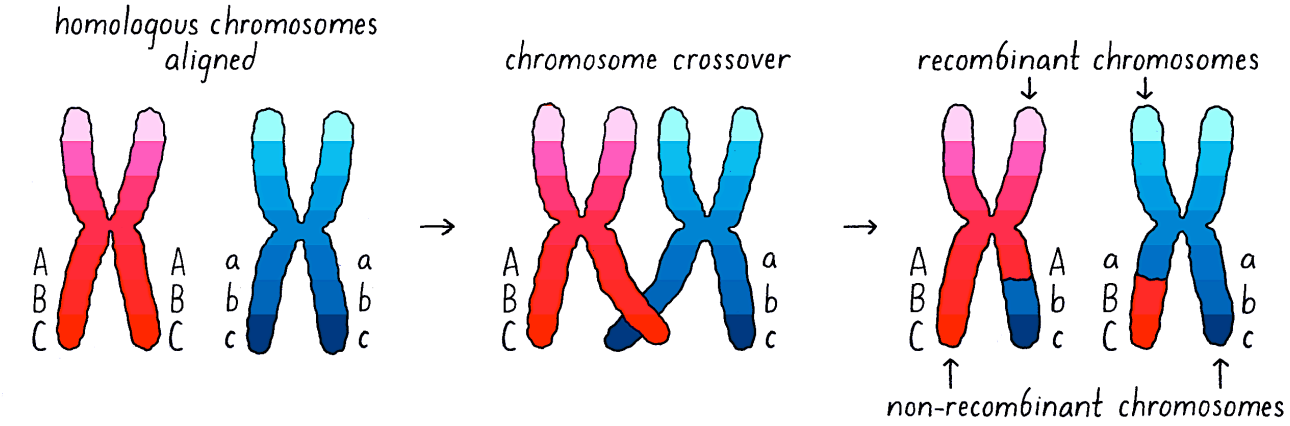
b. Pairing of homologous chromosomes does **not** occur during mitosis. Therefore, crossing over does **not** occur during mitosis either. Homologs do not interact at all during mitosis. So let's review.... Based on what you just learned, **which chromatids exchange identical sections of DNA (and thus identical genes, though potentially different alleles of these genes) during crossing over** once synapsis has occurred during **Prophase I of meiosis**: Sister chromatids of the same chromosome **or** non-sister chromatids of homologous chromosomes? *Include your own labeled drawing to accompany your written answer that showcases which chromatids engage in crossing over.*.

WHAT IS MOST IMPORTANT TO UNDERSTAND ABOUT CROSSING OVER DURING MEIOSIS?

Note that crossing over does **NOT** change the number or types of genes along a chromatid (which will become an unduplicated chromosome in the daughter cell at the end of M phase). **At the end of Prophase 1, the chromatids still contain all the genes for all the same characteristics.** Crossing over **DOES,** however, possibly **alter randomly the alleles of some of the genes** (the version/DNA Sequence of some of the genes) **along the chromatid** (which will become an unduplicated chromosome in the daughter cell at the end of M phase).

Each daughter cell, at the end of meiosis, therefore, inherits a chromosome from the parent cell that carries ALL the necessary genes, but that is NOT genetically identical anymore (in DNA sequence/alleles) to the combination of alleles for all the genes found on either of the two original homologous chromosomes in the parent cell. The resulting chromosome in the daughter cell is a hybrid of the DNA from the two homologous chromosomes in the parent cell. We call this new hybrid chromosome a **recombinant chromosome**.

Again, by creating a recombinant chromosomes, the daughter cell **(the reproductive cell/gamete in animals that will pass DNA on to the future offspring/zygote)** still gets a copy of the required chromosome with all the genes from a parent, but this copy contains a **different COMBINATION of the VERSIONS of all these genes** than the combination the parent originally had on either of its two homologous chromosomes in a pair. ***(*In the image below, pay attention to the combination of alleles for each of the three genes shown on each chromatid prior to and after crossing over.** Remember, each chromatid is a double-stranded DNA molecule (a double helix). Remember too that each of the four chromatids of two homologs will end up becoming one unduplicated DNA chromosome in each of the four daughter cells after the completion of meiosis and cytokinesis).



Every time crossing over occurs in each new parent cell that divides by meiosis to produce new daughter cells, **DIFFERENT sections of non-sister chromatid DNA is exchanged,** resulting in **DIFFERENT types of recombinant chromosomes** forming in new daughter cells. **Crossing over, thus, increases the genetic diversity in and among all offspring** as they inherit these different versions of recombinant chromosomes from their parents after fertilization events produce new zygotes.

10. a. Let's check that you understand. What is different or the same in the daughter cells of a parent cell that underwent **meiosis** as far as the **number of SETS of chromosomes the daughter cells have compared to the parent cell**?

b. What is different in the daughter cells of a parent cell that underwent **mitosis** as far as the **number of SETS of chromosomes the daughter cells have compared to the parent cell**?

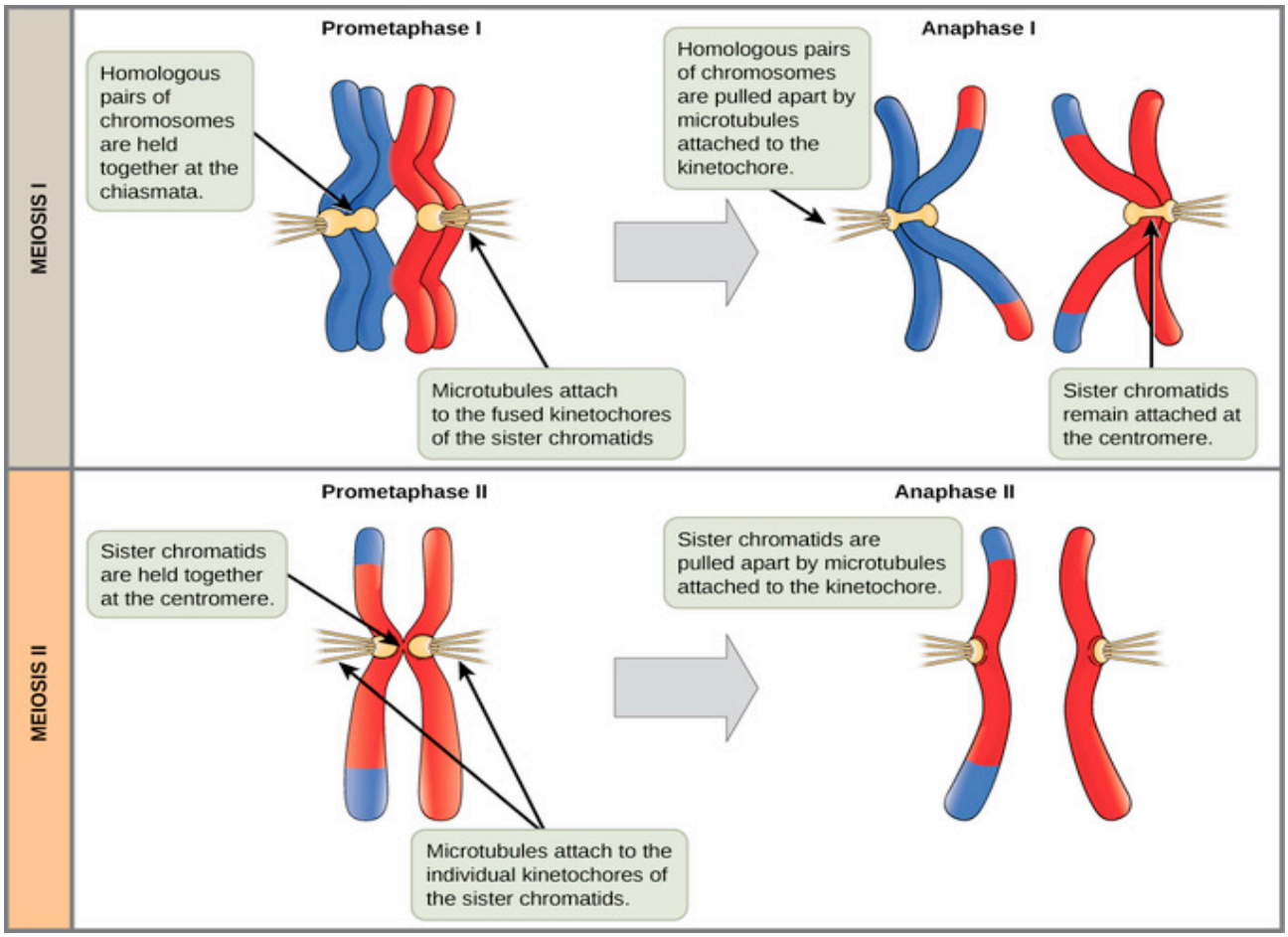
11. State & describe the **three events that are unique to meiosis** ***(not seen in mitosis)***, which take place **during meiosis I**.

1. _____ **=**

2. _____ **=**

3. _____ **=**

12. Using the illustration below, review the **differences in what occurs during Anaphase I and Anaphase II of Meiosis**.



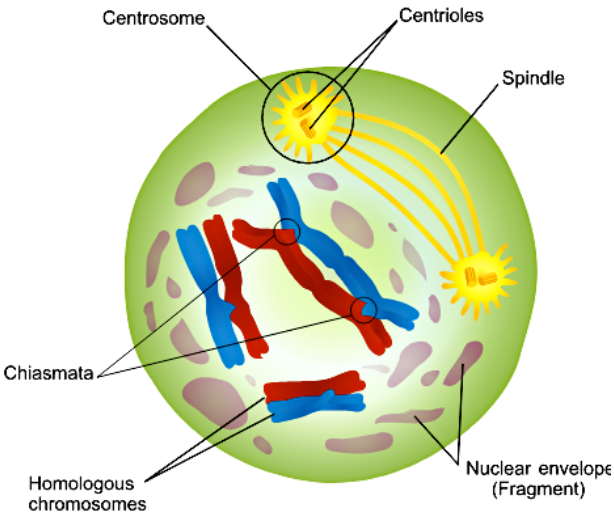
13. Now, compare and contrast what happens during **mitosis versus meiosis** by **studying Figure 13.10** well. In both cases, **DNA is duplicated during S phase of interphase prior to cell division**. Note the parent cells in G1 prior to duplication of their unduplicated chromosomes at the center of the image. These parent cells leave G1, go into S and then G2 phases (not shown), and then start either mitosis or meiosis in M phase. **Memorize this figure & then try question 14.**

14. Let's see if you understand meiosis (and mitosis). Try to answer a-i first without your book. *(Then, check answers to a-i by referring back to Fig.13.10)*

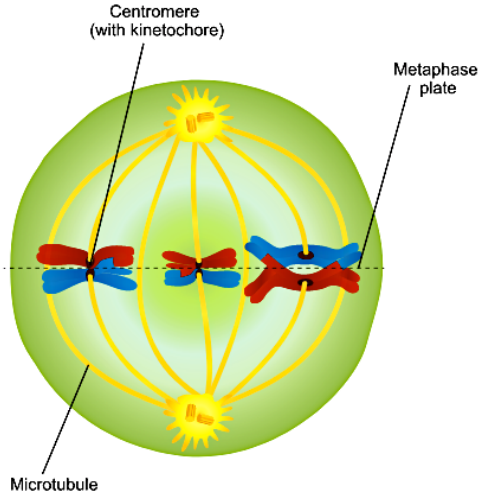
a. How many chromosomes make up **one set** in the cell shown to the right? **(n = ?)**

b. What is the **ploidy** *(number of sets of chromosomes)* of this cell? *Is it haploid (n), diploid (2n), hexaploid (6n) etc?*

c. How many **TOTAL chromosomes** are found in this cell *(not just in a set)*?



d. The figure below shows the cell in **metaphase I**. Using colored pencils or pens to match the red and blue colors of the chromosomes in the illustration below, draw a cell next to this cell to show what this same cell would look like had it been in **metaphase of MITOSIS instead of metaphase I of meiosis I**.



Same cell but in Metaphase of Mitosis

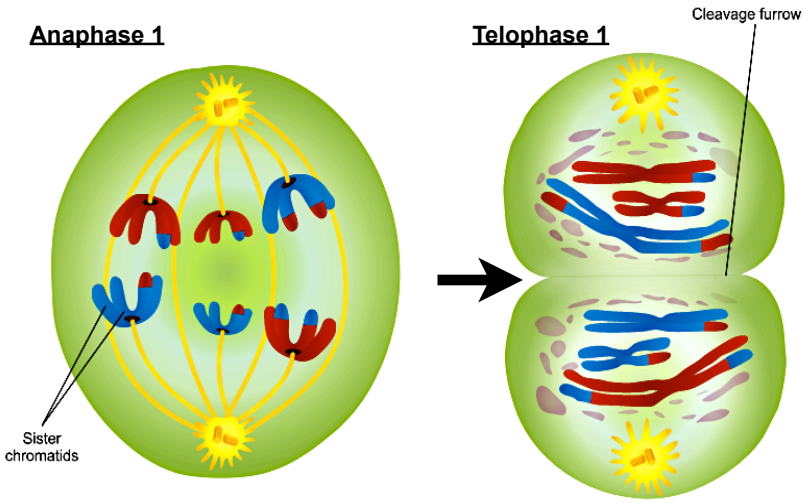
e. Now study the chromosomes of this same cell above as it goes through **anaphase I** and then **telophase I**. How many chromosomes are in each daughter cell at the end of the first meiotic division (see image to your right)?

f. After these two daughter cells finish meiosis II, how many **chromosomes** will the four resultant daughter cells each have?

g. Will these four daughter cells be haploid (n), diploid (2n), triploid (3), hexaploid (6n) etc?

Anaphase 1

Telophase 1



h. Using your red and blue pens or pencils, draw, in the appropriate box below, what the **nucleus of one of the four daughter cells would look like at the COMPLETION of Meiosis II.** *(Make sure you draw your chromosomes correctly in this daughter cell, noting the crossing over that occurred and recombinant chromatids that resulted from Meiosis I as drawn in the figure in 14.e and noting whether chromosomes are duplicated or unduplicated at the start of G1).*

A Daughter Cell Resulting from Meiosis	A Daughter Cell Resulting from Mitosis

i. Now, return to the cell you personally drew in 14.d that was in metaphase of mitosis (not meiosis). In the appropriate box above, **draw what the nucleus would look like of one of the daughter cells that results once your cell completes mitosis.** *(Again, using your red and blue colored pens or pencils, make sure you draw your chromosomes correctly in this daughter cell. Pay attention to whether chromosomes would be recombinant or not, and if they would be duplicated or not at the start of G1, following mitosis).*

15. Take a look at the SCIENTIFIC SKILLS EXERCISE: Making a Line Graph & Converting Between Units of Data. (Remember, the **independent variable is always plotted along the x-axis** while the **dependent variable - what the researcher measures/data collected - is always plotted on the y-axis).**

1. a.

   b.

2. a. & b. *(On graph)*
3. a.

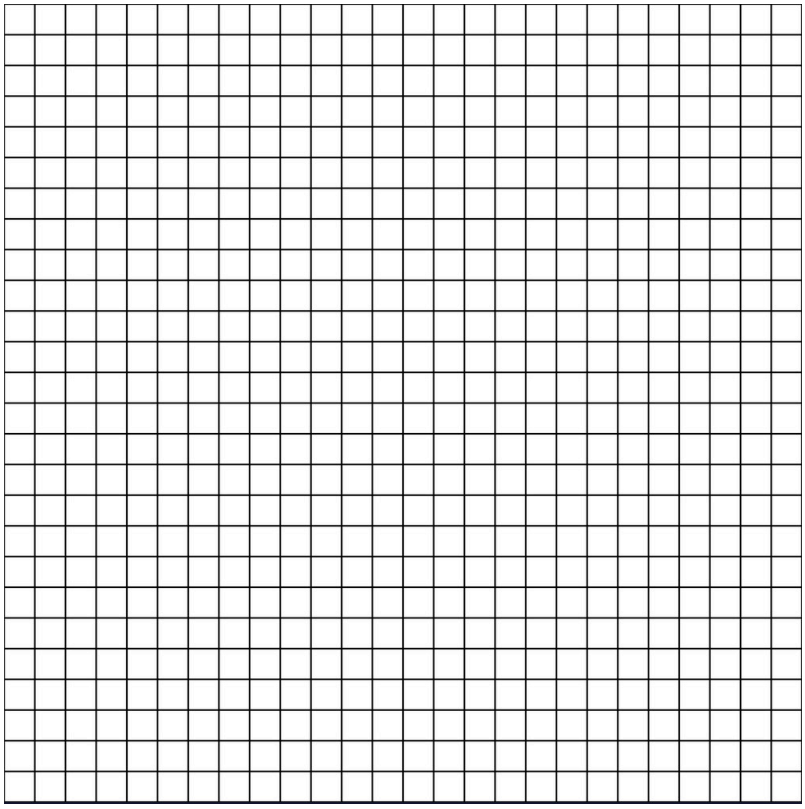
   b.

   c. *(On graph)*

   d.

4. a. *(Always show work)*

   b. *(Always show work)*



16. Here are a few review questions so you can get a sense of if you know the material covered so far in Ch.12 & now 13 well or if you need to review a bit more more **before** continuing on with your Ch.13.4 reading.

a. During which division of meiosis is the chromosome number reduced?

b. What are two important purposes (consequences) of a cell undergoing meiosis?

1.

2.

c. What is the chromosome number at the end of meiosis compared the parent cell at the start of meiosis?

d. What are homologs (homologous chromosomes)? *How may they differ and how are they the same?*

Same in these 3 ways =

May differ in this way =

e. What occurs during synapsis and crossing over?

f. Synapsis and crossing over are unique to meiosis. During what specific phase of of meiosis do these occur?

g. Fill in the chart comparing mitosis and meiosis. *(Use Figure 13.10 to help)*

	Mitosis	Meiosis
Role/Uses in Animal Body		
Number of DNA replications in S phase prior to M phase division		
Number of cell divisions involved		
Number of daughter cells formed		
Relative number of chromosomes in daughter cells		

17. If you feel you have studied everything well up to now and fully understand the behavior of chromosomes during meiosis vs mitosis, continue with your reading of Ch.13.4.