So That's Mitosis!

DIRECTIONS: Can you describe the important events in mitosis yet? Read the following passage one time through, and then read it again answering the accompanying questions.

Mitosis is only a small portion of the overall cell cycle. Most of the cell's life is spent in interphase. During interphase, the cell carries out its normal functioning, whatever is the job of the cell. Also during interphase, the cell grows in size and manufactures DNA to make more chromosomes.

Cell division consists of mitosis (division of chromosomes) and cytokinesis(the actual separation of the cell into two new cells). Cell division only takes up about 10% of the life of the cell, with the remaining 90% in interphase. This includes the replication of chromosomes into homologues, each homologue having a pair of sister chromatids.

When mitosis begins, the chromosomes thicken enough so that the paired homologues and their sister chromatids are visible through a microscope (prophase). The chromosomes then move to and line up on the equator of the cell (metophase). A spindle fiber from each pole attaches to each of the sister chromatids of every homologue. One sister chromatid moves to one pole and the other sister chromatid moves the other pole (anaphase). One of each homologue's sister chromatid clusters at the poles and preparations are made for the cell to separate into two cells (telophase). The cell membrane reforms around each of the two new cells and the two new cell actually separate (cytokinesis). Now there are two, independently functioning cells which will begin the growth process of interphase.

The cell cycle is completed many times, each time producing two cells from one. Because one of each of the sister chromatids of each homologous chromosome is taken into each new cell, the same genes are represented in each new cell. Thus, the two daughter cells as well as the mother cell appear and function identically. It is important to recognize that stages such as prophase and metophase are just names representing the events at that particular time. Mitosis is a continued and gradual process, just as is adolescence. The names of the stages are simply used as reference points for the study of mitosis.

QUESTIONS:

1. What is the cell cycle?

2. What two important processes occur in the cell during interphase?

3. What happens generally during mitosis?

4. What happens to the chromosomes during prophase?

5. What happens to the chromosomes during metaphase?

6. What happens to the chromosomes during anaphase?

7. What happens to the chromosomes during telophase?

8. What happens to the cell during cytokinesis?

9. How are the daughter cells similar to the mother cell?

10. Why do cell need to divide instead of increasing in size?

11. What are two other reasons cells divide?

ARE THERE MORE DIVIDING CELLS OR RESTING CELLS IN A ROOT TIP

A plant grows in length at the tip of a stem and root. In the stem and root tip there is a small group of cells that divide many times; however, not all cells in these parts may be dividing. A dividing cell may be next to several resting cells and a resting cell can be surrounded by several dividing cells.

Cells in mitosis are different from resting cells. Some parts of a cell are seen best only when a cell is dividing. These parts seem to disappear after a cell had divided.

Keywords: Define the following keywords:

Dividing cell _____

Resting cell _____

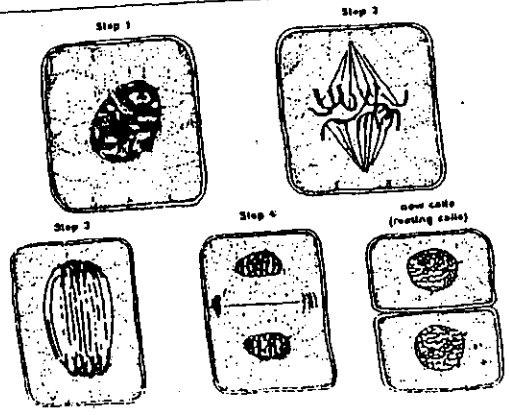
Root tip _____

Table 1

Steps of Mitosis	Number of Cells Seen
Prophase	
Metaphase	
Anaphase	
Telophase	
Interphase Resting Cells	
Total Cells Seen	

Figure 1

Student Drawings



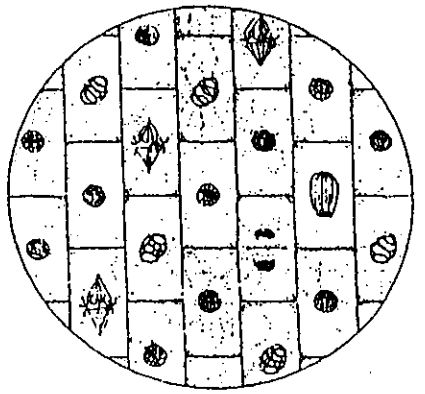
H2

11. A biology student was looking at an onion root tip through the microscope and made a drawing of the cells she saw. Record on the chart how many cells you think she saw that were either resting cells or dividing cells.

Table 2 Cells seen by the student.

Steps of Mitosis	Number of Cells Seen
Prophase	
Metaphase	
Anaphase	
Telophase	
Interphase Resting Cells	
Total Cells Seen	

Figure 2



Questions

1. What part is seen in the resting cells that is missing in cells that are dividing?

2. What parts are seen in dividing cells that are not visible in the resting cells?

3. Why do you think new cells are sometimes called resting cells?

4. Which cells did you see more of in the onion root, dividing cells or resting cells?

5. Which step of mitosis was most common in the onion root?

6. Which step of mitosis was least common in the onion root?

7. Suppose you examined another root tip and saw that half of the cells were dividing. Would this root be growing faster or slower than the one you examined in this exercise? Explain your response.

Animal Mitosis

INTRODUCTION

a. The process of cell development described in this set is called _____

b. The specimen studied is the egg sac of the ascaris worm. Why?

_____

_____

SLIDE 1 - THE ZYGOTE

a. This slide shows the zygote -- the fertilized egg of the ascaris. How many masses of chromatin can you see in the cell?

_____

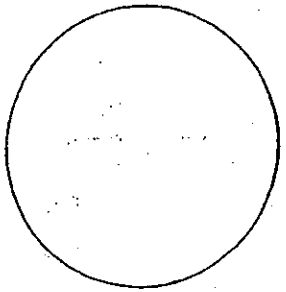
b. Where did these masses come from? _____

_____

_____

c. The amount of hereditary material supplied by each parent of the ascaris is (equal) (not equal). Underline your choice.

SLIDE 2 - PRO-METAPHASE



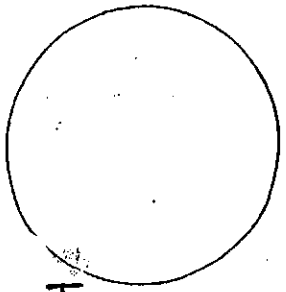
a. Draw what you see in this slide.

b. How many chromosomes can you see? _____

c. Each parent supplied _____ chromosomes to form the zygote.

d. Label the chromosomes supplied by the sperm

SLIDE 3 - METAPHASE



a. Draw what you see in this slide.

b. Label the equatorial plate; a centriole; spindle fibers.

SLIDE 4 - METAPHASE - POLAR VIEW

a. How does this picture differ from that in slide 3?

_____

_____

_____

b. In this slide the chromosomes are seen as they lie flat on the _____ plane.

SLIDE 5 - EARLY ANAPHASE

a. How many chromosomes are shown in this slide? _____ (Hint: Compare with slide 3)

b. The number of chromosomes in this slide contain enough hereditary material for _____ cells.

SLIDE 6 - ANAPHASE

a. The chromosomes in this slide have separated to form _____ groups. Each group contains _____ chromosomes.

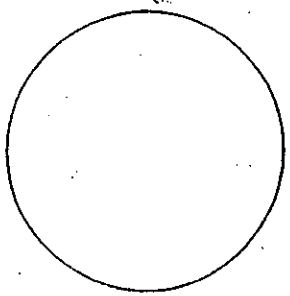
b. Why do some of the chromosomes appear to be beaded in places?

_____

_____

_____

SLIDE 7 - TELOPHASE



a. Draw what you see in this slide.

b. The two groups of chromosomes are (still connected) (completely apart from each other). Underline your choice.

c. What is happening to the cell membrane?

_____

_____

SLIDE 8 - LATE TELOPHASE

a. How many cells are seen in this slide? _____

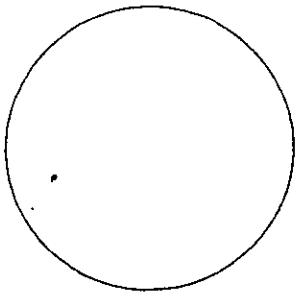
b. How do these cells compare with the cell in slide 1?

_____

c. How many chromosomes are involved in human mitosis? _____

MVL: PLANT MITOSIS

Slide 1: Prophase

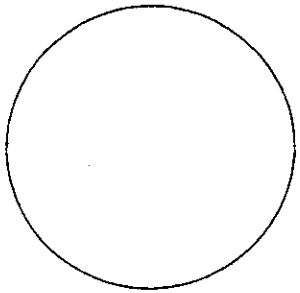


a. At what stage does mitosis begin? _____. Draw a cell that illustrates the beginning of mitosis.

b. Another term for the "resting phase" is _____

c. At what stage do the chromosomes duplicate themselves? _____

Slide 3: Metaphase

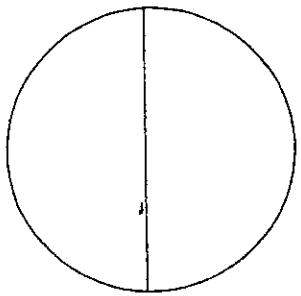


a. Draw this stage of mitosis as you see it in Cell C. Label the doubled chromosomes in the drawing.

b. This stage is called _____

c. The chromosomes line up in the middle of the cell at a place called: _____

Slide 5: Anaphase



a. Draw this stage of mitosis as you see it in Cell E on the left side of the circle template. Draw this stage of mitosis as you see it in Cell B on the right side of the circle template.

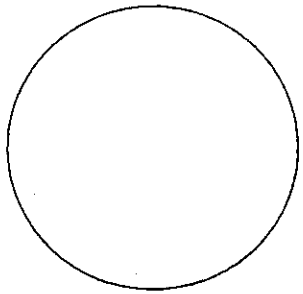
b. At what stage is Cell E? _____

c. At what stage is Cell B? _____

d. How many sets of chromosomes are visible in Cell E? _____ *(Remember this is a diploid cell)*

HH

Slide 7: Telophase



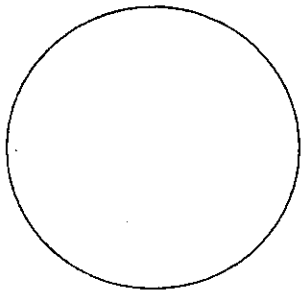
a. Draw this stage of mitosis as you see it in Cell G. Label the doubled chromosomes in the drawing.

b. What does the horizontal line through the middle of Cell G represent? _____.

c. Compare the cell at the extreme upper right side of the slide 2 with Cell G. How is it the same/ how is it different?

- Which cell is further advanced, the cell in slide 2 of Cell G?

Slide 8: Late Telophase



a. Draw cell H. At what stage is Cell H? _____

b. If the original Cell A contained 16 chromosomes, the number of chromosomes found in each new cell (labeled H) will be

a. 8
b. 16
c. 24
d. 32
e. 48

So That's Meiosis!

DIRECTIONS: Can you describe the important events in meiosis yet? Read the following passage one time through, and then read it again answering the accompanying questions?

Meiosis takes place in gametes (sex cells), rather than somatic (body cells). The daughter cells are haploid (1N) meaning there is one chromosome from each homologous pair. Meiosis is divided into two sequences: meiosis I and meiosis II. During interphase in meiosis I, the chromosomes are replicated and become large enough to be visible under a classroom microscope. In prophase I, segments of homologous chromosomes can become exchanged, a process called crossing over. This is a possible source of variation of offspring. In metaphase I, the chromosomes line up at an imaginary equator. Each member of a pair of chromosomes (a homologue) is also made up of two sister chromatids. This gives the appearance of four chromosomes of the same kind. In meiosis I each homologous chromosome of each chromosome pair stays together until anaphase I. During anaphase I, the homologous pairs separate, one of each pair going to one pole and the other going to the opposite pole. Each of these different homologues will eventually end up in a different sperm or egg cell. Why? Because if an individual is heterozygous for a trait that is located on a given pair of homologous chromosomes, different alleles for this trait will appear in the sperm or egg cells. This is one of the evolutionary causes of variation in the next generation.

When meiosis II begins, the homologous pairs with their sister chromatids have separated into different cells. The major event in Meiosis II occurs during anaphase II. This is when the sister chromatids separate, producing only one sister chromatid from each original chromosome pair in each new egg or sperm. Note that at the end of meiosis, each of four resulting daughter cells has only one chromosome and this chromosome is not paired with its homologue. In the human, sperm and egg cells have only 23 chromosomes. All other human cells, including a newly formed fertilized egg, have 23 pairs of chromosomes (46). Another function of meiosis II is to produce lots of sperm or egg cells.

1. In what type of cells does meiosis occur?

2. How many chromosomes from each homologue are there in daughter cells?

3. What important event occurs in prophase I?

4. What important event occurs in anaphase I?

5. What is the evolutionary significance of meiosis I?

6. If each human sperm and egg had the same number of chromosomes as all the other cells, how many chromosomes would be present in a fertilized egg? What is the problem with this?

7. Why does meiosis I separate the pair of homologous chromosomes into different cells?

8. Why does meiosis II separate the sister chromatids into different cells?

9. How many sperm and egg cells does meiosis produce? Why is this important?

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9. SYNTHESIS: COMPARING MITOSIS AND MEIOSIS

In asexual reproduction, the new individuals are the product of mitosis. In sexual reproduction, a new individual is the result of the union of a female gamete and a male gamete. Fill out the chart comparing meiosis and mitosis, and then answer the questions that follow.

	Mitosis	Meiosis
Cell type of parent cell (diploid or haploid)		
Number of daughter cells produced		
Cell type of daughter cells		
Number of cell divisions		
Genetic relationship of daughter cells to parent		
Genetic relationship of daughter cells to one another		

1. Synapsis occurs in _____ but not in _____.
2. After stage _____ of meiosis, the daughter cells are haploid.
3. Why is it necessary for stage II of meiosis to occur? _____
4. Stage _____ of meiosis is most similar to mitosis because _____
5. Every zygote is a _____ cell because it comes from _____

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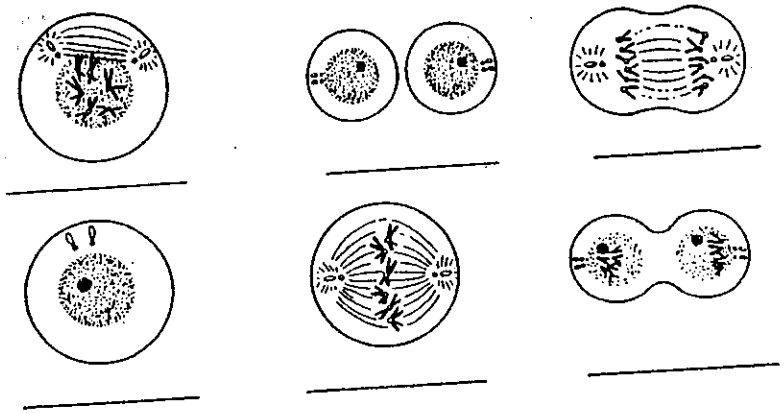
COMPARING MITOSIS AND MEIOSIS

Determine whether the following characteristics apply to mitosis, meiosis or both by putting a check in the appropriate column(s).

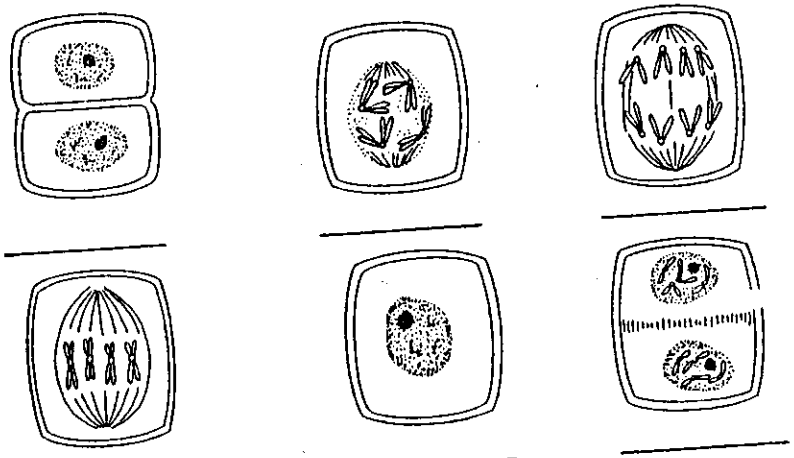
	Mitosis	Meiosis
1. no pairing of homologs occurs		
2. two divisions		
3. four daughter cells produced		
4. associated with growth and asexual reproduction		
5. associated with sexual reproduction		
6. one division		
7. two daughter cells produced		
8. involves duplication of chromosomes		
9. chromosome number is maintained		
10. chromosome number is halved		
11. crossing over between homologous chromosomes may occur		
12. daughter cells are identical to parent cell		
13. daughter cells are not identical to parent cell		
14. produces gametes		
15. synapsis occurs in prophase		

STAGES OF MITOSIS

Number the following six diagrams of the stages of mitosis in animal cells in the proper order. Label each stage with the proper name.

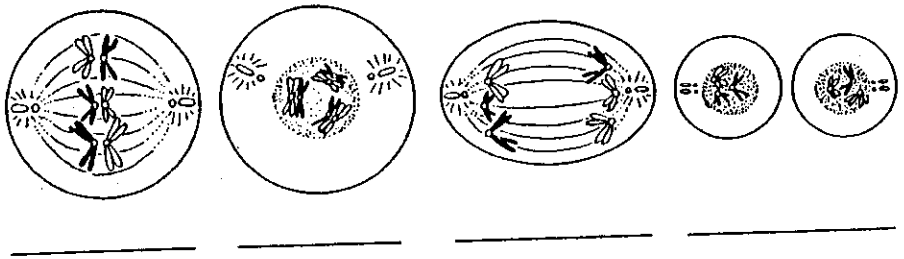


Do the same for the following diagrams of mitosis in plant cells.

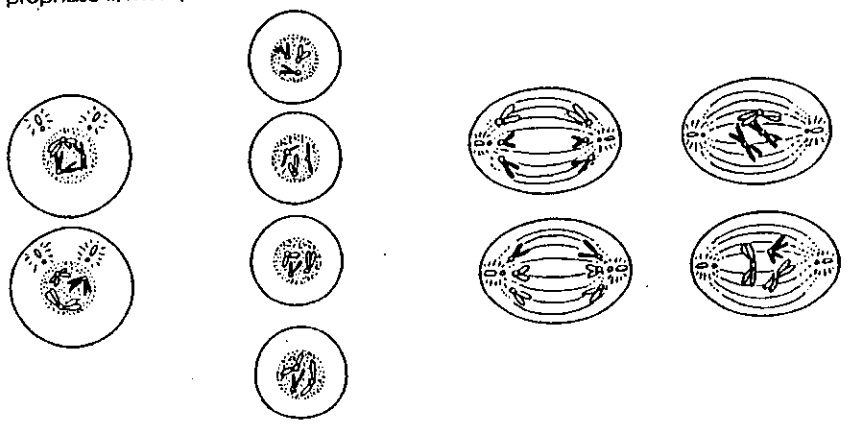


STAGES OF MEIOSIS

Number the following diagrams of a first meiotic division in the proper order. Label each phase correctly as prophase I, metaphase I, anaphase I or telophase I.



Do the same for the diagrams of the second meiotic division. Label each phase correctly as prophase II, metaphase II, anaphase II, telophase II .



Chromosome Simulation Analysis Q's and Summary

Directions: As you complete the Chromosome Simulation Activity, answer the following questions in complete sentences on separate paper

II. Mitosis Simulation

Interphase

1. How many chromosomes are present in the original cell prior to DNA replication? What colors are they?
2. How many chromosomes are present in the original cell after DNA replication?
3. What differences (if any) are there between the original and replicated chromosomes?

Prophase

1. What does the string represent?

Telophase

1. How many chromosomes are present in each cell at the end of mitosis? What colors are they?
2. What differences (if any) are there between the original and replicated cells?

Summary- Explain the following for mitosis.

>purpose
>type of cells
>parent cell chromosome #(haploid/diploid)
>daughter cell chromosome #(haploid/diploid)
># nuclear divisions
>#daughter cells

III. Meiosis Simulation

Interphase

1. How many chromosomes are present in the original cell after Interphase?
2. So far, what differences (if any) are there between mitosis and meiosis?

Meiosis 1(1st Division)

1. Why did the chromosomes form tetrads?
2. How many chromosomes are present in each cell?
3. Are the results of Meiosis 1 any different from that which occurs after 2 cells are formed in mitosis? Explain.

Meiosis 2(2nd Division)

1. How many cells are formed at the end of meiosis?
2. What is the total number of chromosomes present in each new cell after meiosis?
3. Do any of the new cells contain 2 blue or 2 orange chromosomes? Explain why or why not.
4. Are the results of Meiosis 2 any different from that which occurs after mitosis? Explain.

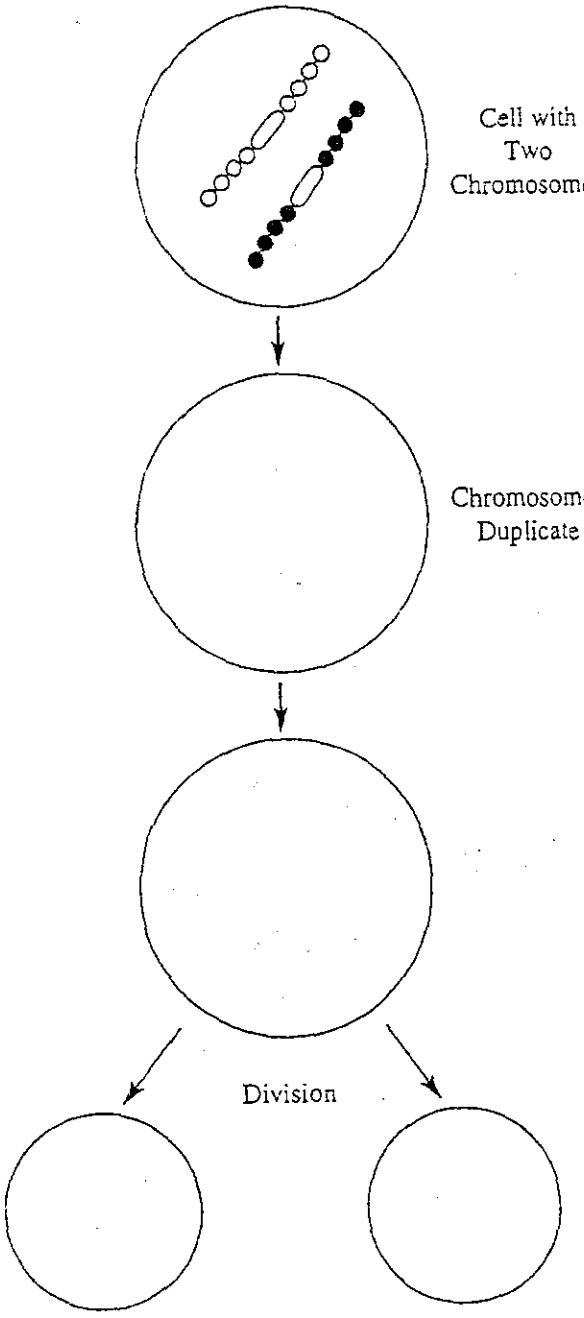
Summary- Explain the following for meiosis.

purpose
type of cells
parent cell chromosome #(haploid/diploid)
daughter cell chromosome #(haploid/diploid)
nuclear divisions
#daughter cells

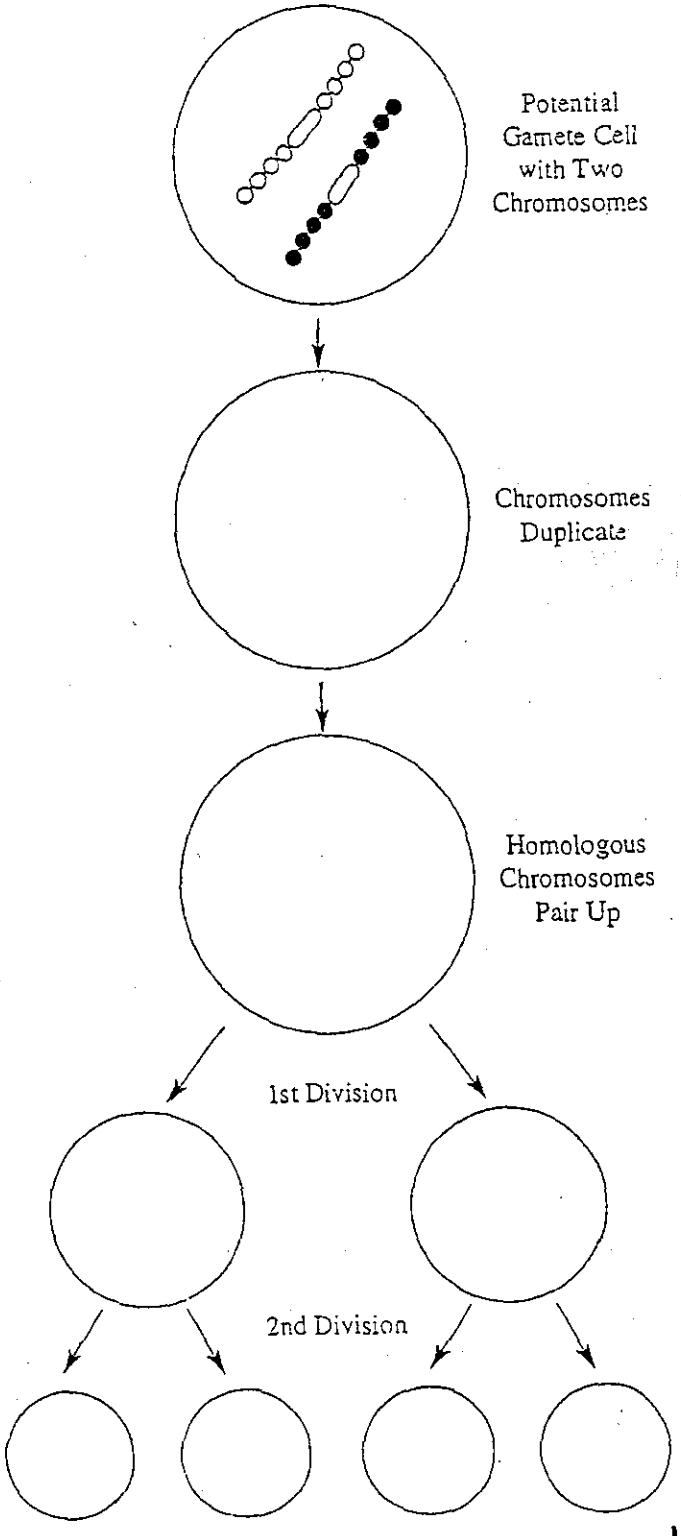
Chromosome Simulation Summary Chart

Directions: Copy the circular templates from below including descriptions/labels. Add in the correct number and color of chromosomes for each stage.

Mitosis



Meiosis



Name_____

Mitosis and Meiosis
Interactive Video Quiz

Directions: Fill in the blank with the correct answer or circle True or False.

Part 1 Mitosis

1.The state of mitosis seen here is called _____.

2. Chromatin shortens and thickens to form these distinct structures called_____.

3. DNA is replicated during the stage between cell divisions called _____.

4. True or False: The division of the cytoplasm following mitosis is called cytokinesis.

5. The first stage of mitosis, the stage when the nuclear membrane begins to be reabsorbed into the cell, is called _____.

Part 2 Meiosis

1. As a result of meiosis, sex cells are formed that have _____ the number of chromosomes of body cells.

2. True or False: Pairs of identical chromosomes are also called homologous chromosomes.

3. True or False: Normal body cells are diploid because they possess one of each different chromosomes.

4. True or False: During meiosis, the DNA is replicated twice.

5. True or False: In plant and animal cells, meiosis occurs only in germ cells.

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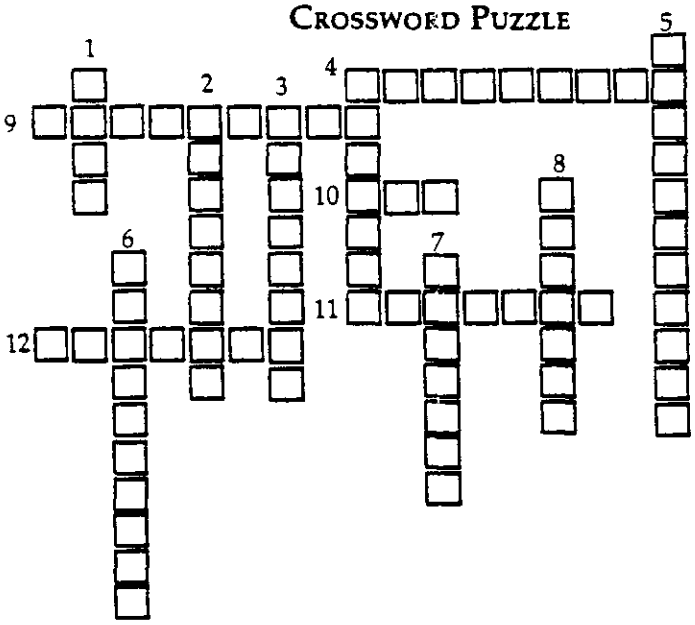
Name_____

Mitosis and Meiosis

Crossword Puzzle



Down

1. Only _____cells can undergo meiosis.
2. When a cell first starts to undergo mitosis, it loses its nuclear membrane and chromosomes are formed from chromatin. This stage of mitosis is called _____.
3. Chromosomes move rapidly toward the mitotic centers during _____.
4. Sperm and egg cells result from a special type of cell division called _____.
5. DNA undergoes a process called _____when it is duplicated.
6. When a cell is not undergoing the process of mitosis, it is in a stage called _____.
7. If an organism possesses just four different kinds of chromosomes and yet its cells have a total of eight chromosomes, eight would be its _____number of chromosomes.
8. For the organism described above in the previous question, its _____number of chromosomes is four.

Across

4. Duplicated chromosomes are arranged in the middle of the spindle during _____.
9. The stage of mitosis that happens at the same time the cytoplasm divides is called _____.
10. Eggs are also called _____.
11. The arrangement of microtubules that become visible during mitosis and that separate the chromosomes into equal groups is called the _____.
12. Telophase is the final stage of _____.

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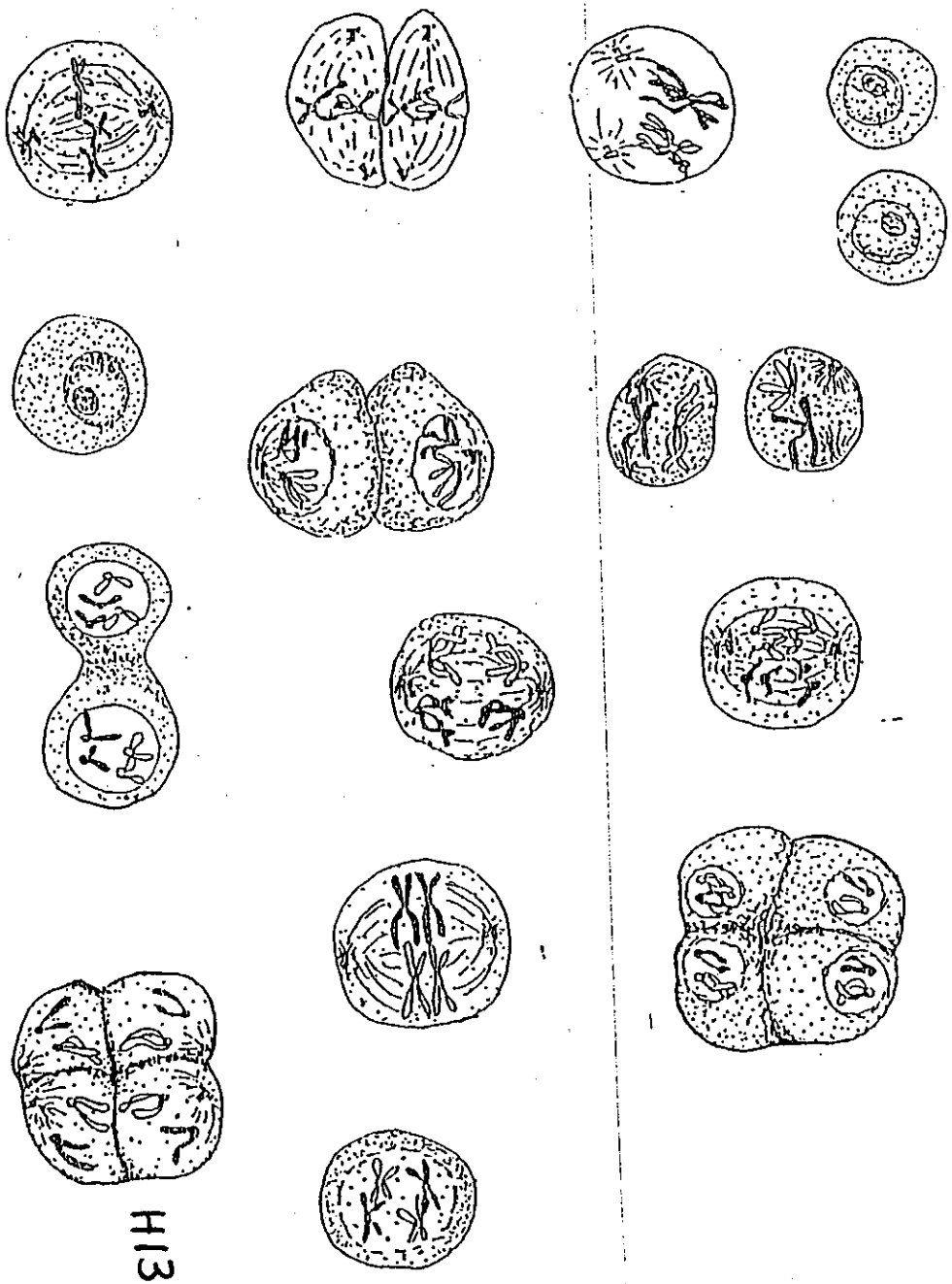
Cut out the following diagrams. Separate into three piles: Mitosis, Meiosis I, Meiosis II. Arrange in proper sequence within each pile. Glue them on the paper provided, in order, to show the process of mitosis and meiosis.



H13

Use the following words as labels for your diagrams. Use each as many times as necessary. Add any additional labels you wish.

process of mitosis	process of meiosis	telophase I	telophase II
prophase	prophase I	prophase II	spermatogenesis
metaphase	metaphase I	metaphase II	oogenesis
anaphase	anaphase I	anaphase II	2n/diploid
telophase	cytokinesis	interphase	1n/haploid
tetrad	centromere	spindle fibers	centrioles
homologous chromosomes		sister chromatid	

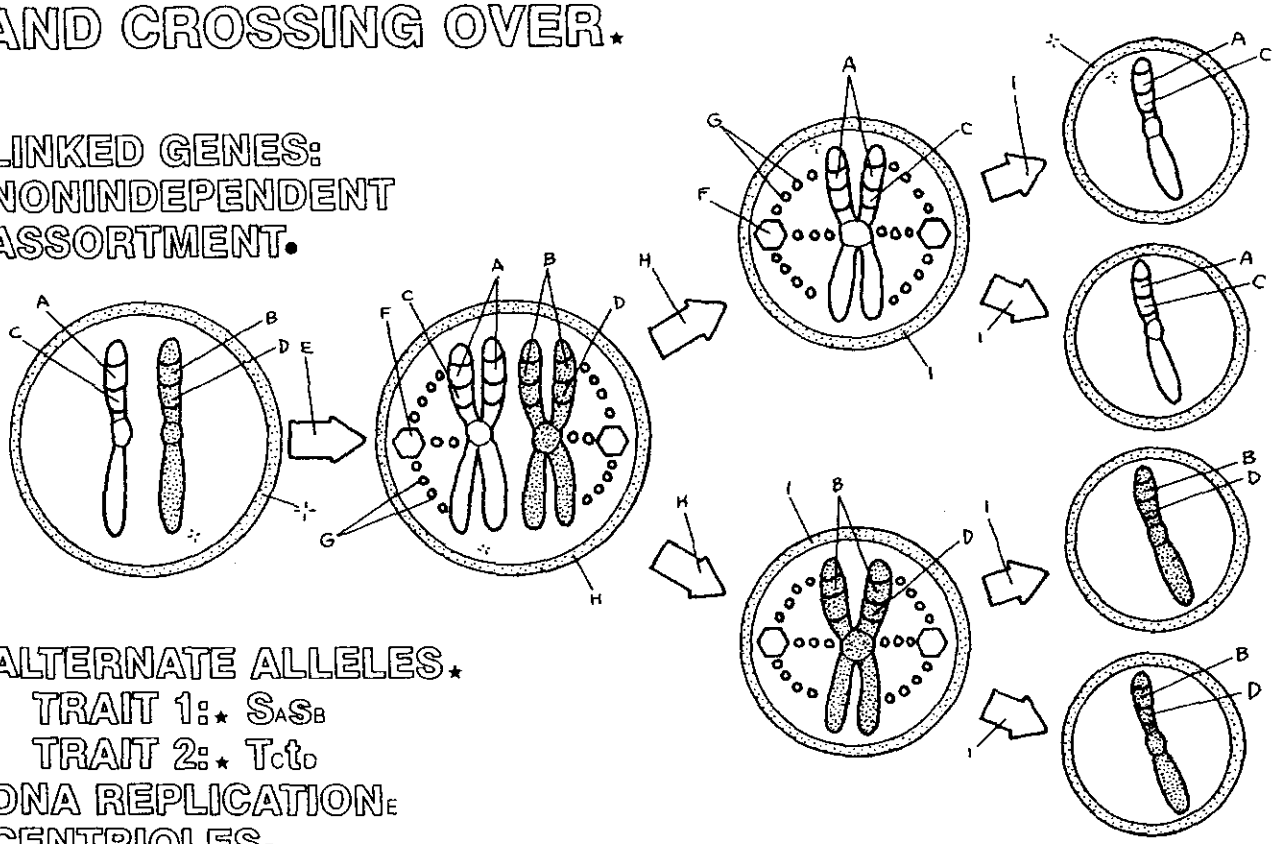
Use the following phrases to describe what happens in the appropriate phase of mitosis or meiosis. Add any additional phrases you wish to fully explain each phase of mitosis and meiosis.

- synapse occurs in this phase
- homologous chromosomes are arranged in tetrads in this phase
- two, genetically identical diploid cells produced at end of this phase
- four haploid cells produced at end of this phase
- chromosomes are pulled to opposite ends of the cell with centromere intact
- cell cytoplasm and organelles divide in this phase
- centromere splits and chromatids move to opposite sides of the cell.
- occurs in somatic cells
- homologous chromosomes line up on metaphase plate
- process that produces new cells to repair or replace old or damaged body cells
- nuclear membrane reforms around chromosomes in this phase
- process that produces gametes in males and females
- produces 1 ovum
- occurs in gonads
- diploid chromosome number
- produces 4 sperm haploid sperm cells

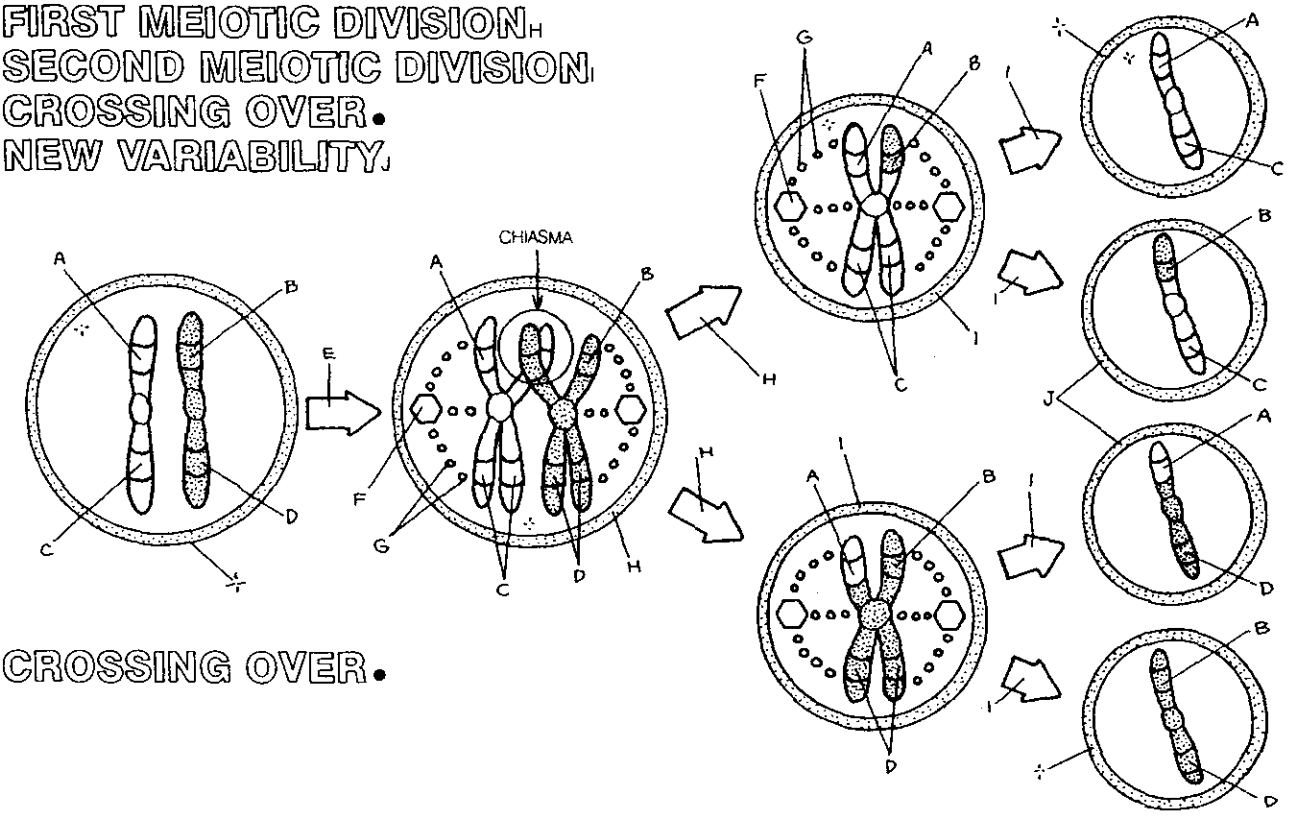
LINKED GENES AND CROSSING OVER★

GAMETES★

LINKED GENES: NONINDEPENDENT ASSORTMENT●



ALTERNATE ALLELES★
TRAIT 1:★ $S_A s_B$
TRAIT 2:★ $T_c t_D$
DNA REPLICATION$_E$
CENTRIOLES$_F$
MEIOTIC SPINDLE$_G$
FIRST MEIOTIC DIVISION$_H$
SECOND MEIOTIC DIVISION$_I$
CROSSING OVER●
NEW VARIABILITY$_J$



CROSSING OVER●

BCB: Linked Genes and Crossing Over

1. What are linked genes? Where are linked genes located?

2. What are "linkage groups"?

3. Explain crossing over.
   a. In what type of cells does it takes place?

   b. When does it take place?

   c. What chromosomes are involved?

   d. What is the result?

   e. Where does it occur?

4. What is the relationship between the distance that separates genes and the likelihood that crossing over will separate them?

5. List four genetic mechanisms that lead to variation.

6. Why is variation important to the survival of living things?

Mendel's Law of Independent Assortment applies only to genes located on different pairs of homologous chromosomes. In contrast, linked genes, which are located near one another on the same chromosomes, sort together. And the closer two genes lie on a chromosome, the more likely they are to "stay together." Genes that lie in close proximity to one another are called "linkage groups." Most of the research on linkage groups has focused on X-linked traits (those carried by genes on the sex chromosomes). The pattern of inheritance of a certain genetic defect involving the nails and knee caps has been found to follow the same pattern of inheritance as ABO blood groups (Plate 37 and 38).

Color the top half of the plate. Color the two alleles for trait 1 (S and s) and the two alleles for trait 2 (T and t) with four contrasting colors.

The first cell shown is an oogonium (sex cell in the female) or a spermatogonium in the male (see Plate 30). This individual is heterozygous for both traits 1 and 2.

In preparation for the *first meiotic division,* the *DNA replicates* (represented by the arrow) and produces two identical sister chromatids. Notice how the *first meiotic division* segregates homologous chromosomes into separate primary gametocytes. In the *second meiotic division,* four haploid gametes are produced. Notice that alleles for traits 1 and 2 have not sorted independently during meiosis. Alleles S and T, for example, are "packaged" on a single chromosome in the parent and remain exclusively together in the ova or spermatids.

Do genes located on the same chromosome always stay together? Not necessarily. Meiosis is an extremely complex process, involving two cellular divisions and forty-six strands of DNA, each several million nucleotides in length. All this replicating and sorting takes place within the microscopic confines of a tiny cell. It should come as no surprise then that meiosis is not the perfectly executed process we have described. During the *first meiotic divison,* chromosomes frequently "exchange" parts. This process is called the crossing over of linked genes.

Use the same four allele colors to follow the fate of linked genes through meiosis, when crossing over occurs.

Notice that our hypothetical traits are determined by genes whose loci are farther apart than in the above example, but they are still linked on the same chromosome. During anaphase of meiosis I, nonsister homologous chromatids may overlap, as you see here. Through rearrangements in molecular bonding, segments of the DNA are exchanged. The place where crossing over occurs is called the chiasma. There may be several chiasmata along a single homologous pair. This means that the farther apart two genes are located on a chromosome, the more likely it is that crossing over will take place at some point between them and the greater the possibility that they will become "unlinked" during the *first meiotic division.* Genes that are very close together, however, have a much greater chance of staying together and of segregating nonindependently, as in the first example at the top of the plate. With crossing over, alleles S and s exchange places; so after the *second meiotic division,* two gametes contain chromosomes that carry a novel combination of alleles for traits 1 and 2.

Notice that these two new combinations of alleles were not present in the genome of the individual who produced them. Crossing over contributes new varieties of individual genotypes in the next generation.

We have seen that mutations (Plate 23), the independent segregation of chromosomes during meiosis (Plate 30), the recombination of genes during sexual reproduction (Plate 31), and the crossing over of linked genes all introduce variability into the gene pool. This vast pool of variation between individuals becomes ordered into patterns of evolutionary change by natural selection. Those individuals, or those genetic variants, best suited to the environment into which they are born will survive and will contribute a larger portion of their genes to the next generation. Darwin made this proposal in the nineteenth century, knowing nothing of the genetic mechanisms underlying heredity. He had no explanation for the origin of new variation. The twentieth-century biological sciences have provided many answers. Now we understand how the genetic information is shuffled, reshuffled, and maintained over generations. The biochemical behavior of DNA during replication and sex cell division is apparently introducing genetic variation to the gene pool at a fairly constant rate, hence the molecular clock. The missing pieces of Darwin's theory have fallen into place.