AP BIOLOGY NAME_____
EVOLUTION/HEREDITY UNIT
Unit 1 Part 3 Chapter 12 DATE_____PERIOD_____
Activity #3

CELL CYCLE

INTRODUCTION

The nuclei in cells of eukaryotic organisms contain chromosomes with clusters of **genes**, discrete units of hereditary information consisting of double-stranded DNA. Structural proteins in the chromosomes organize the DNA and participate in DNA folding and condensation. When cells divide, chromosomes and genes are duplicated and passed onto daughter cells. Single-celled organisms divide for *reproduction*. Multicellular organisms have reproductive cells (eggs and sperm), but they also have somatic (body) cells that divide for *growth* or *reproduction*.

In body cells and single-celled organisms, the nucleus divides by **mitosis** into two daughter nuclei, which have the same number of chromosomes and the same genes as the parent cell. Division of the nucleus is generally followed by division of the cytoplasm (**cytokinesis**).

Events from the beginning of one cell division to the beginning of the next are collectively called the **cell cycle**. The cell cycle is divided into four stages: G_1, S, G_2, and M. In interphase (G_1, S, G_2) DNA replication and most of the cell's growth and biochemical activity take place. The M stage represents the division of the nucleus and cytoplasm.

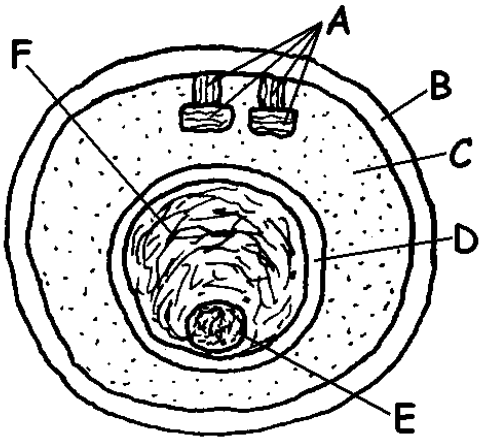
PART I – ANIMAL CELL CYCLE

INTERPHASE

During interphase, a cell performs its specific functions. Liver cells produce bile; intestinal cells absorb nutrients; pancreatic cells secrete enzymes; skin cells produce keratin. Interphase consists of three stages, G_1, S, and G_2, which begin as a cell division ends. As interphase begins, the cytoplasm in each cell is approximately half the amount present before division. Each new cell has a nucleus that is surrounded by a **nuclear envelope** and contains chromosomes in an uncoiled state. In this uncoiled state, the mass of DNA and protein is called **chromatin**. Throughout interphase one or more dark, round bodies, called **nucleoli**, are visible in the nucleus. Two **centrioles** are located just outside the nucleus.

1. Color the following parts on the diagram at the right:

- Centrioles (A)
- Cell Membrane (B)
- Cytoplasm (C)
- Nuclear Envelope (D)
- Nucleolus (E)
- Chromatin (F)



In the gap 1 (G_1) phase, the cytoplasmic mass increases and will continue to do so throughout interphase. Proteins are synthesized, new organelles are formed, and some organelles such as mitochondria and chloroplasts, grow and divide in two.

During the **synthesis (S) phase**, the chromosomes replicate. This involves replication of the DNA and associated proteins. Each chromosome is now described as **double-stranded** and each strand is called a **sister chromatid**.

During the gap 2 (G_2) phase, in addition to continuing cell activities, cells prepare for mitosis. Enzymes and other proteins necessary for cell division are synthesized during this phase. At the end of G_2 the centrioles divide and begin to move to opposite poles (sides) of the cell. Also, microtubules are organized around the centrioles. The centriole with its microtubules is referred to as the **aster**. The centrioles are located in an area called the **centrosomes** or microtubule organizing centers.

2. List the three phases of interphase and briefly describe what happens during each phase.

Phase	Description

M PHASE (MITOSIS AND CYTOKINESIS)

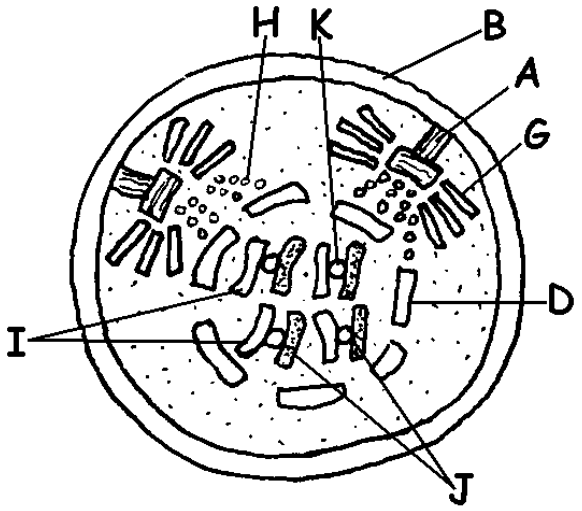
In the M phase, the nucleus and cytoplasm divide. Nuclear division is called **mitosis**. Cytoplasmic division is called **cytokinesis**. Mitosis is divided into four phases: prophase, metaphase, anaphase, and telophase.

EARLY PROPHASE

Prophase begins when chromatin begins to coil and condense (become shorter and thicker). At this time they become visible in the light microscope. Centrioles continue to move to opposite poles of the cell, and as they do so, a fibrous, rounded structure tapering toward each end, called a **spindle**, begins to form between them. As prophase continues, the nucleoli disassemble.

3. Color the following parts on the diagram at the right:

- Centrioles (A)
- Cell Membrane (B)
- Nuclear Envelope (D)
- Asters (G)
- Spindle (H)
- Chromatid (I)
- Chromatid (J)
- Centromere (K)



4. Briefly describe what happens during early prophase.

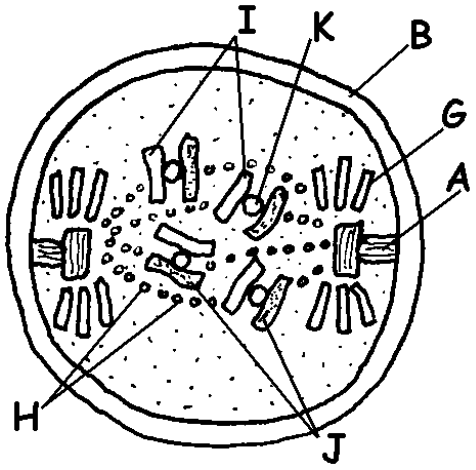
Early Prophase	

LATE PROPHASE (PROMETAPHASE)

As prophase continues, the chromatin forms clearly defined chromosomes that consist of two chromatids joined together at the **centromere**. As the spindle continues to form, the nuclear envelope breaks apart. The spindle is made of microtubules organized into fibers. Some of the spindle fibers attach to the chromosomes in the **kinetochore** region of the **centromere**. These microtubules are referred to as **kinetochore microtubules.** The kinetochore microtubules move the chromosomes to the equation (metaphase plate) of the cell. Kinetochore and nonkinetochore microtubules make up the spindle fibers. The centrioles are at opposite poles and with the spindle fibers extending between them.

5. Color the following parts on the diagram at the right:

- Centrioles (A)
- Cell Membrane (B)
- Asters (G)
- Spindle (H)
- Chromatid (I)
- Chromatid (J)
- Centromere (K)



5. Briefly describe what happens during late prophase.

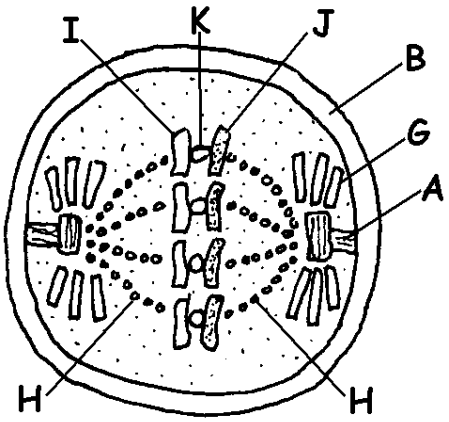
Late Prophase (Prometaphase)	

METAPHASE

In metaphase, double-stranded chromosomes line up at the center of the cell with the centromeres aligned along the equator (metaphase plate) of the cell.

7. Color the following parts on the diagram at the right:

- Centrioles (A)
- Cell Membrane (B)
- Asters (G)
- Spindle (H)
- Chromatid (I)
- Chromatid (J)
- Centromere (K)



8. Briefly describe what happens during metaphase.

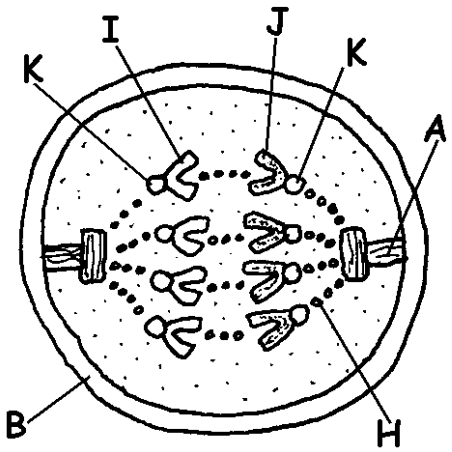
Metaphase	

ANAPHASE

Anaphase begins when the centromeres "break" and move apart. Each chromatid is now called a **chromosome**. The kinetochore microtubules shorten at the point of attachment within the centromere. This shortening results in the movement of the chromosomes toward the poles of the cell. Anaphase ends as the chromosomes reach the poles.

9. Color the following parts on the diagram at the right:

- Centrioles (A)
- Cell Membrane (B)
- Spindle (H)
- Chromosome (I)
- Chromosome (J)
- Centromere (K)



10. Briefly describe what happens during anaphase.

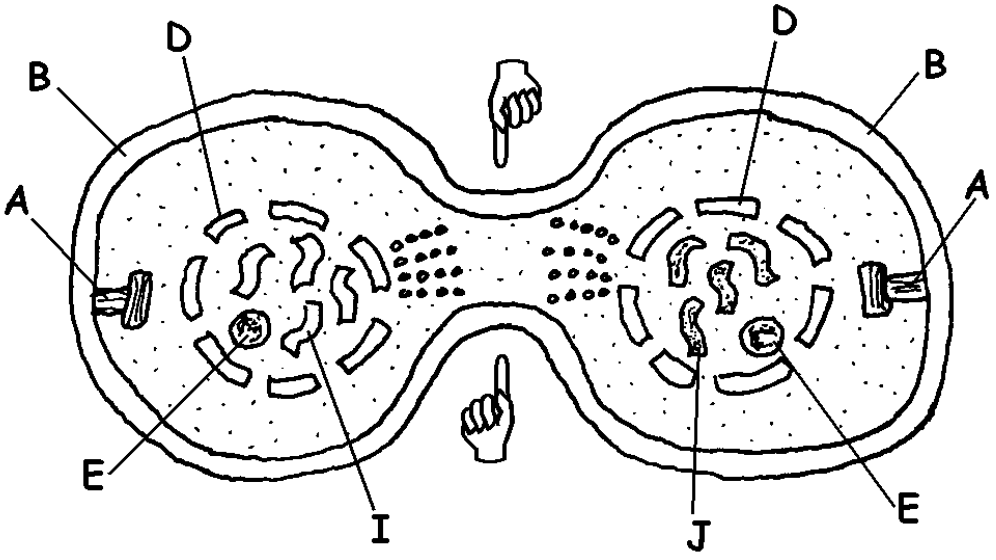
Anaphase	

TELOPHASE/CYTOKINESIS

As chromosomes reach the poles, anaphase ends and telophase begins. The nonkinetochore microtubules elongate the cell. Chromosomes begin to uncoil. A nuclear envelope forms around each new cluster of chromosomes and the nucleoli reform. Telophase ends when the nuclear envelopes are complete. The end of telophase marks the end of nuclear division, or mitosis. Sometime during telophase, the division of the cytoplasm to form two separate cells (cytokinesis) begins. During cytokinesis in animal cells, a **cleavage furrow** (a shallow groove) forms at the equator. A contractile ring consisting of actin microfilaments forms along the metaphase place. As the ring contracts, the diameter of the cell at the metaphase plate decreases and the cell is pinched in two.

11. Color the following parts on the diagram below:

- Centrioles (A)
- Chromosomes (I)
- Cell Membrane (B)
- Chromosomes (J)
- Nuclear Envelope (D)
- Cleavage Furrow (hand)
- Nucleolus (E)



12. Briefly describe what happens during telophase and cytokinesis.

Telophase	
Cytokinesis	

PART II: COMPARING PLANT AND ANIMAL CELL MITOSIS

13. Obtain a set of Mitosis Pictures from the Supply Area.

14. Examine the pictures comparing Plant and Animal Cell Mitosis

15. What are the major differences between mitosis in animal cells and mitosis in plant cells?

Animal Cell Mitosis	Plant Cell Mitosis

16. For each picture the Mitotic Phase Identification Cards, determine the phase represented in the picture and indicate if the cell is plant or animal.

Slide #	Mitotic Phase	Animal or Plant	Slide #	Mitotic Phase	Animal or Plant
1			7		
2			8		
3			9		
4			10		
5			11		
6			12		

PART III: TIME FOR CELL REPRODUCTION

It is hard to imagine that you can estimate how much time a cell spends in each phase of cell replication from a slide of dead cells. Yet this is precisely what you will do in this part of the activity. You will count the number of cells in each phase and they infer the percent of time each cell spends in each phase.

17. Examine the cells in Microscopic Field #1 of the Time for Mitosis Pictures. Determine the cell cycle phase for each cell present in the field of view. Record the numbers in the Time for Mitosis Data Table.

18. Repeat step 17 for each of the eight microscopic fields.

19. Calculate the total number of cells in each phase and the total number of cells viewed. Record the totals in the Time for Mitosis Data Table.

20. Calculate the percentage of cells in each phase.

21. It takes, on average, 24 hours (1,440 minutes) for onion root-tip cells to complete the cell cycle. Using this information you can calculate the amount of time spent in each phase of the cell cycle using the percent of cells in that stage. (Percent of cells in phase times 1,440 minutes). Calculate the time spent in each phase and record your results in the data table.

Time for Mitosis Data Table

Field	# of Cells in Interphase	# of Cells in Prophase	# of Cells in Metaphase	# of Cells in Anaphase	# of Cells in Telophase
1					
2					
3					
4					
5					
6					
7					
8					
Total					
% of Total Cells Counted					
Time in Each Phase					

22. Based on the data you collected, what can you infer about the relative length of time an onion root-tip cell spends in each stage of cell division?

_____

_____

_____

PART IV: QUESTIONS

1. What are the three key roles of cell division? State each role, and give an example.

Key Role	Example

2. What is meant by the *cell cycle*? _____

_____

12.1

3. What is a genome? _____

4. How many chromosomes does a human somatic cell have? _____

5. Name two types of somatic cells in your body

_____

6. What is a gamete? _____

7. Name two types of gametes _____

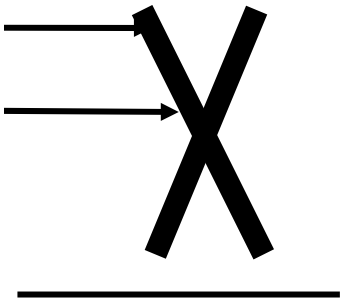
8. How many chromosomes does a human gamete have? _____

9. What is Chromatin? _____

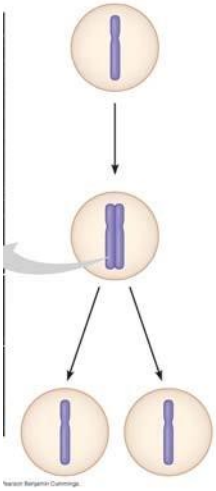
10. How many DNA molecules are in each of your somatic cells? _____

11. You are going to have to learn the difference between a number of similar-sounding terms. The sketch that looks like an X represents a *replicated chromosome* that has two *sister chromatids*. The narrow "waist" represents the location of the *centromere*. Students often get all these terms confused, so take time now to **label** the indicated areas of the figure and then **define** each of the terms below.

chromosome **chromatid** **centromere** **chromatin**



12. Study Figure 12.5. Label the figure below, and summarize what occurs at the DNA level in each stage.



13. What is *mitosis*? How is it different from *cytokinesis*?

_____

_____

_____

14. What occurs in *meiosis*? How is the chromosome number of daughter cells different?

_____

_____

_____

15. Select either *mitosis* or *meiosis* to answer the following questions.

_____By what process are the damaged cells in a wound replaced?
_____By what process are eggs formed?
_____By what process does a zygote develop into a multicellular organism?
_____In which process are identical daughter cells produced?
_____Which process reduces chromosome number of daughter cells?

16. A hedgehog has 90 chromosomes in its somatic cells.

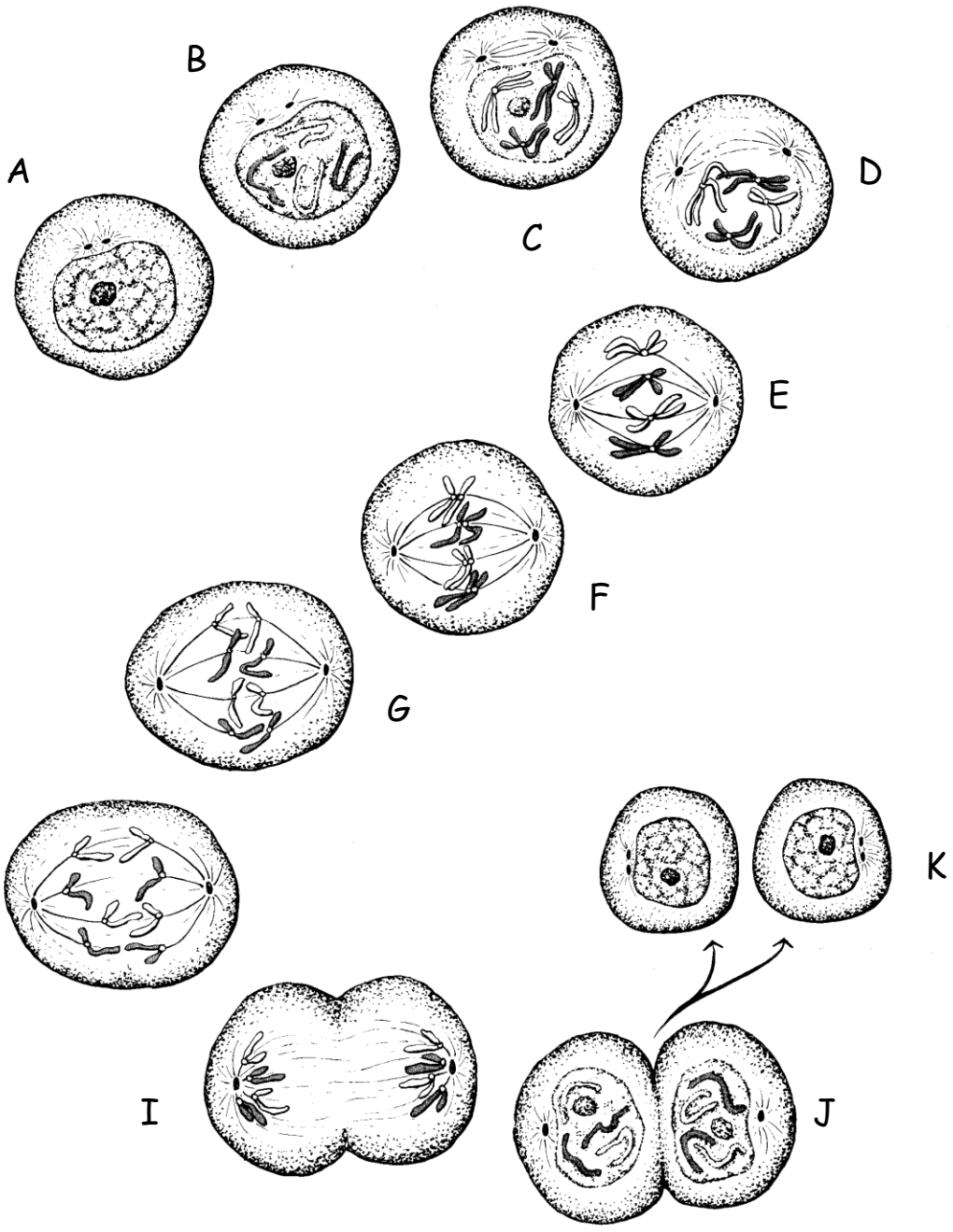
a How many chromosomes did the hedgehog inherit from each parent? _____

b How many chromosomes are in each of the hedgehog's gametes? _____

c How many chromosomes will be in each somatic cell of the hedgehog's offspring? _____

12.2

17. Use the drawings below to answer the questions that follow.



a What mitotic phase is shown in cell A?_____

b What mitotic phase is shown in cells B, C, D, and E?_____

c What mitotic phase is shown in cell F?_____

d What mitotic phase is shown in cells G and H?_____

e What mitotic phase is shown in cells I and J?_____

f What mitotic phase is shown in cell K?_____

18. Are the cells pictured in Question 17 animal or plant?_____

How do you know?_____

_____

19. In what way are the newly formed cells, which result from mitosis, similar to the mother cell?

_____

_____

How are they new cells different?

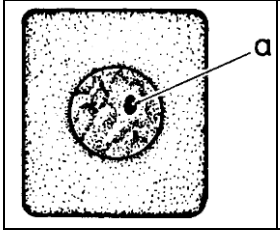
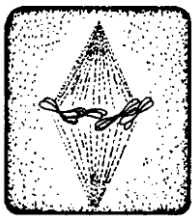
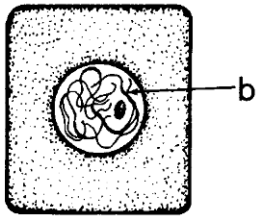
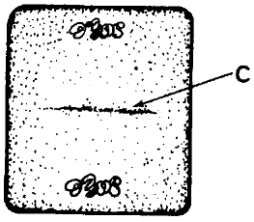
_____

20. Why is it necessary for DNA to replicate before mitosis begins?

_____

_____

21. Examine the diagrams below.

Cell #1	Cell #2	Cell #3	Cell #4
			

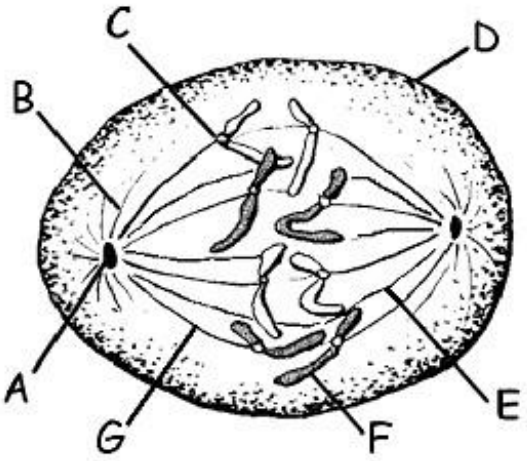
Name the structure indicated by letter a in cell #1._____

Name the structure indicated by letter b in cell #3._____

Name the structure indicated by letter c in cell #4._____

What is the correct order of the diagrams?_____

22. Match the structure with the correct letter from the diagram.



_____ Cell Membrane

_____ Centromere

_____ Centriole

_____ Chromosome

_____ Aster

_____ Kinetochore microtubules

_____ Nonkinetochore microtubule

23. Match the description/event with the correct mitotic phase. Use the key below to indicate your answers.

A = Anaphase **M = Metaphase**
P = Prophase **PM = Prometaphase**
T = Telophase

_____ Nucleoli disappear
_____ Chromatin coils & folds (condenses)
_____ Mitotic spindle forms
_____ Centrosomes separate and move to opposite poles of cell
_____ Nuclear envelope fragments
_____ Kinetochore microtubules attach to kinetochores
_____ Chromosomes move to metaphase plate
_____ Centromeres of each chromosome "break" and move apart
_____ Sister chromatids separate and are referred to as chromosomes
_____ Spindle fibers move the chromosomes to opposite poles
_____ Nonkinetochore microtubules elongate the cell
_____ Daughter nuclei form at each pole
_____ Nuclear envelopes form around each set of chromosomes
_____ Nucleoli reappear
_____ Chromatin uncoils (decondenses)
_____ Chromosomes line up along the metaphase plate

24. What are the components of the *mitotic spindle*? What is the source of these components?

_____

_____

25. In animal cells, the assembly of spindle microtubules starts at the *centrosome*. What is another name for the centrosome?

_____

_____

_____

26. Sketch and label a centrosome with two centrioles.

27. Describe what happens to the centrosome during interphase and then prophase.

_____

_____

_____

_____

28. What is a *kinetochore*? Read your text carefully, and then **make** a labeled sketch that shows a replicated chromosome with two kinetechores and some attached spindle fibers. Figure 12.8 may help.

29. At which end do kinetochore microtubules shorten during anaphase? Explain the data that supports where this shortening occurs. Figure 12.9 may help.

_____

_____

_____

30. Describe *cytokinesis* in an animal cell. Use a labeled sketch that shows the *cleavage furrow*.

31. Describe cytokinesis in a plant cell. Use a labeled sketch that shows the *cell plate*.

32. How is the cell plate formed? What is the source of the material for the cell plate?

33. Prokaryote reproduction does not involve mitosis, but instead occurs by *binary fission*. This process involves an *origin of replication*. Describe binary fission.

34. How do prokaryotes differ from eukaryotes?

    Membrane-bound organelles?

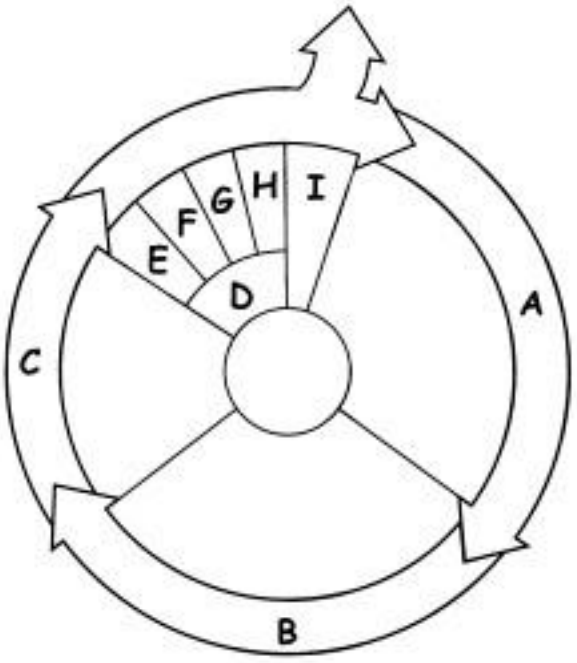
    Mode of reproduction?

    Number of chromosomes?

    Shape of bacterial chromosome?

12.3

35. Match the event or description with the correct cell cycle phase.



_____ Mitosis
_____ DNA replication
_____ Cytokinesis
_____ Cell grows in size
_____ Organelles replicate
_____ Interphase
_____ Division of nuclear contents
_____ Division of cytoplasm
_____ G_1 (gap 1)
_____ G_2 (gap 2)
_____ S phase
_____ Cell prepares for cell division
_____ Prophase
_____ Anaphase
_____ Metaphase
_____ Telophase
_____ Chromosomes condense (coil and fold)
_____ Chromosomes uncoil
_____ Chromosomes pulled to opposite poles of cell
_____ Chromosomes line up along the equator of the cell

36. What directs the sequential events of the cell cycle?

_____

37. What is the significance or importance of the checkpoints in the cell cycle?

_____

38. For many cells, what seems to be the most important checkpoint?

_____

What happens to the cell if it meets the requirements of this checkpoint?

_____

What happens to the cell if it fails to meet the requirements of this checkpoint?

_____

_____

39. Summarize what happens at each checkpoint and how it is controlled.

Checkpoint	**What happens? How is it controlled?**
G_1	
G_2	
M	

40. Define or describe each of the following:

Protein Kinase	
Cyclin	
Cdks	
MPF	

41. Explain how MPF is involved in the control of the cell cycle.

_____

_____

_____

_____

42. Describe how the concentration of each of the following changes during the cell cycle:

Cdk	
Cyclin	
MPF	

43. What is the role of proteolytic enzymes in the cell cycle?

_____

44. What internal and external cues help regulate the cell cycle?

_____

_____

45. Define or describe the following:

Growth Factor	
Density dependent Inhibition	
Anchorage Dependence	

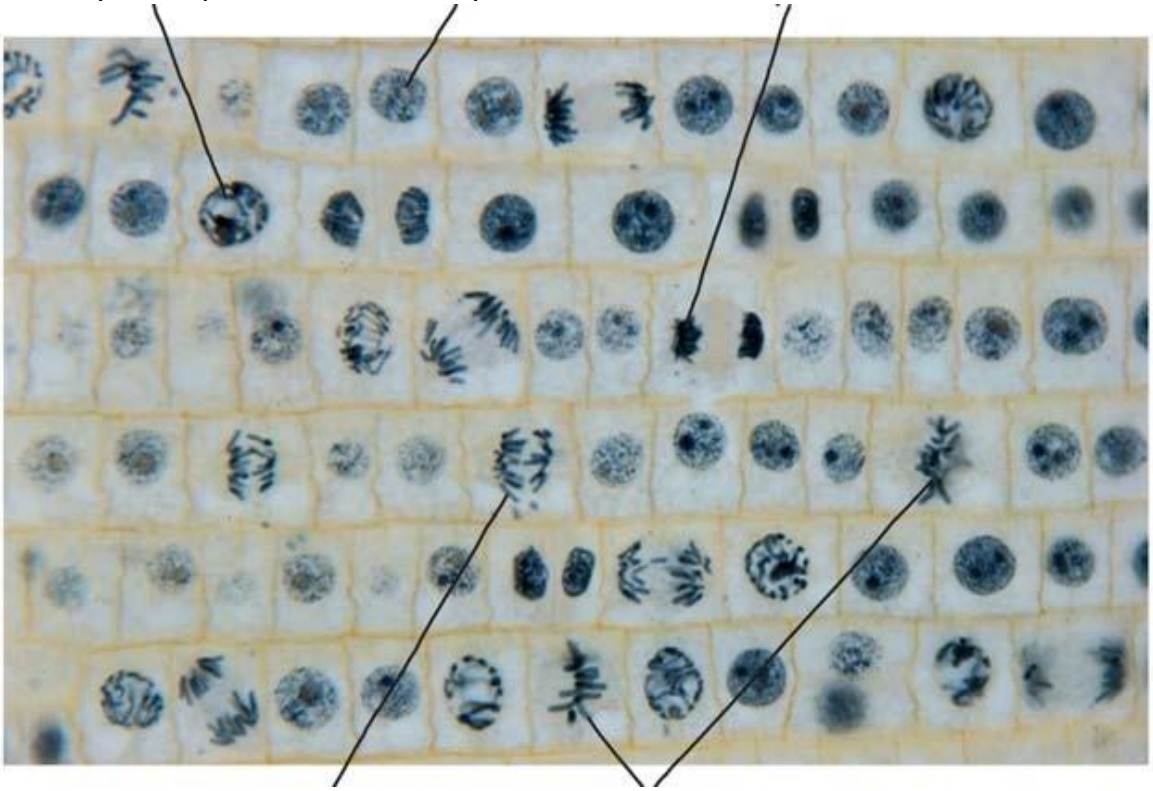
46. How are cancer cells different from normal cells?

Cancer Cells	Normal Cells

47. Define the following:

Transformation	
Tumor	
Benign Tumor	
Malignant Tumor	
Metastasis	

48. Identify each phase of the cell cycle.



End of the Chapter Synthesis and Evaluation Problems

Do problems 1-9, 11, and 13. Check and correct your answers to 1-9 and 11 in the back of the text.

1._____
2._____
3._____
4._____
5._____
6._____
7._____
8._____
9._____

***Question 13 should be typed out, then answered in no more and no less than 100 to 150 words. Turn in separately to the tray. This is worth **20 points!** So not plagiarize! Use your own words and thoughts...but, use vocabulary terms and ideas taught in this chapter!

11. _____

_____

_____

_____

_____

_____

_____

Study Guide/ISN (20 points)

In your study guide book, review pages 66-70. In your ISN, do the following: Title the page **Chapter 12: The Cell Cycle Must Know!** In one color, copy down each of the must know items listed on page 66 in study guide leaving space underneath to include in a 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.

Bozeman Science/AP Biology/ISN (See syllabus for format) (**20 points each)**

1. Using Mathematics (AP Biology Practices)
2. Cell Cycle, Mitosis and Meiosis (Big Idea 3)