AP Biology **Interactive Student Study Guide**

North Salem University

MISSION: *Engage students to continuously learn, question, define and solve problems through critical and creative thinking.*

Fall 2023

Now that you know how DNA replicates itself, we will now take a more holistic look at how this DNA (*chromatin* ⟶ *chromosomes*) get passed from cell to cell via mitotic cell division with a focus on the checkpoints and mechanisms that control this very important process along with the disease that results when this process continues out of control – cancer.

If you have any problems – please sign up for extra help after school.

Ch.12
The Cell Cycle and Cancer

Chapter 12: The Cell Cycle

OBJECTIVES:

The Key Roles of Cell Division

__1. Explain how cell division functions in reproduction, growth, and repair.
__2. Describe the structural organization of the genome.
__3. Describe the major events of cell division that enable the genome of one cell to be passed on to two daughter cells.
__4. Describe how and why the chromosome number changes throughout the human life cycle.

The Mitotic Cell Cycle

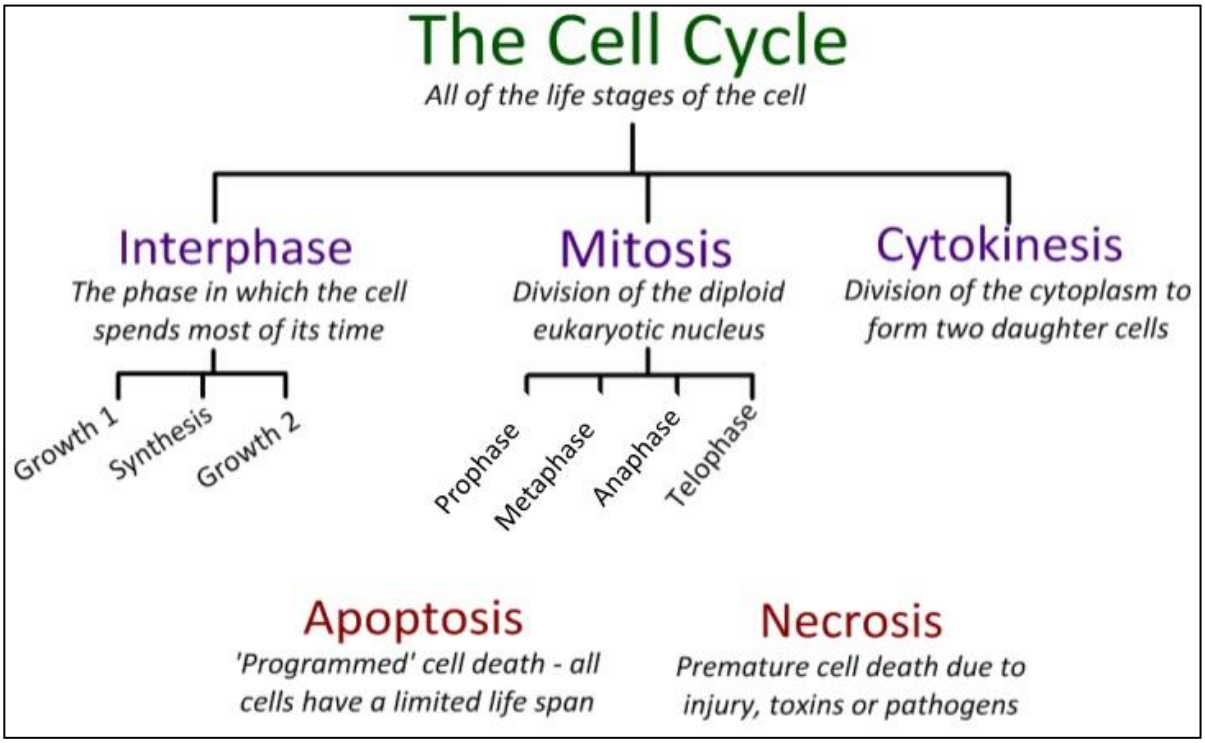
__5. List the phases of the cell cycle and describe the sequence of events that occurs during each phase.
__6. List the phases of mitosis and describe the events characteristic of each phase.
__7. Recognize the phases of mitosis from diagrams and micrographs.
__8. Compare cytokinesis in animals and plants.
__9. Describe the process of binary fission in bacteria and how this process may have evolved in eukaryotic mitosis.

Regulation of the Cell Cycle

__10. Describe the roles of checkpoints, cyclin, Cdk, and MPF in the cell cycle control system.
__11. Describe the internal and external factors that influence the cell cycle control system.

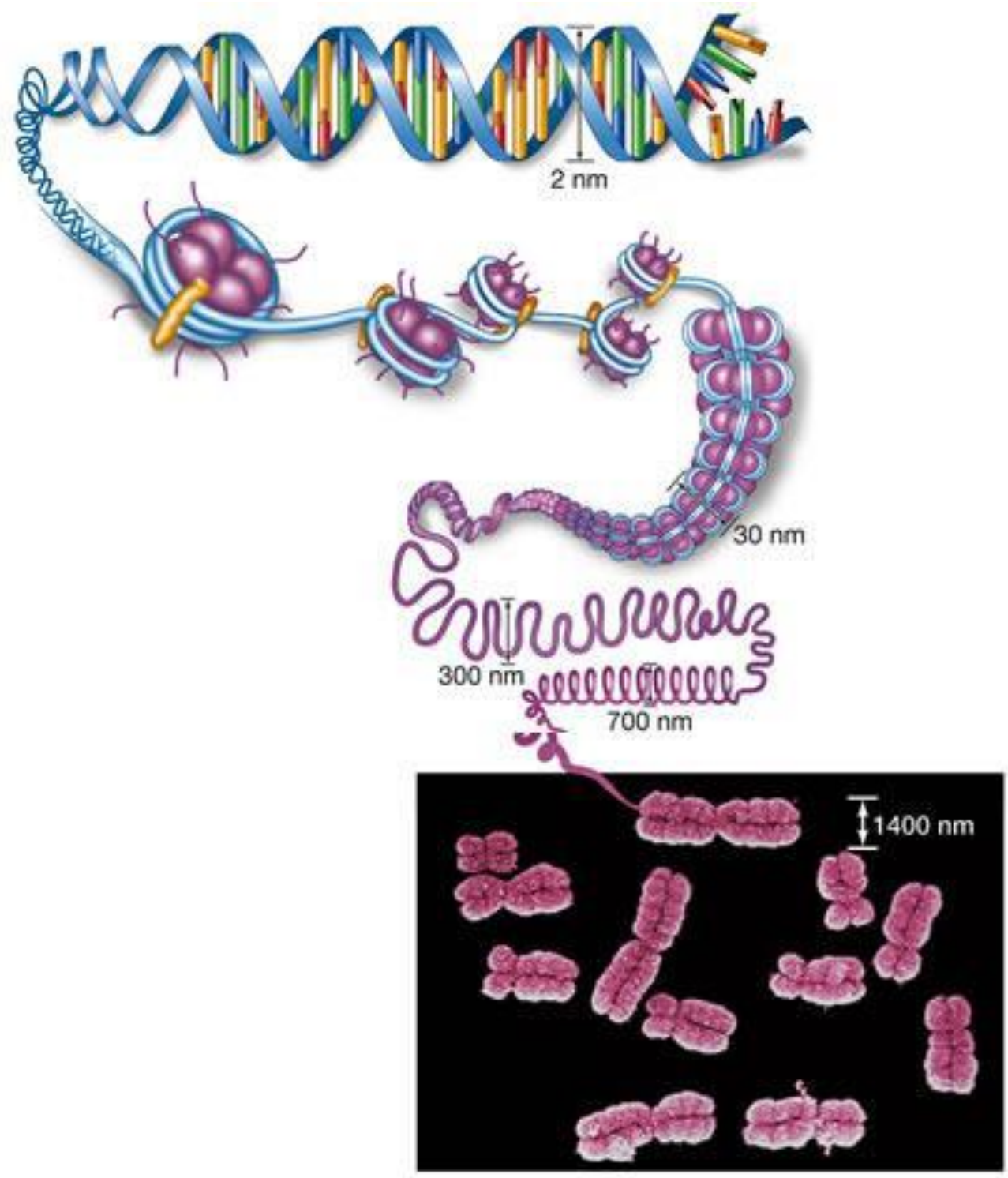
Science as a Process

__12. Explain how the abnormal cell division of cancerous cells differs from normal cell division.



Guided Reading: Chapter 12

Organization of Eukaryotic Chromosomes



The Key Roles of Cell Division

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

(a)

(b)

(c)

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

3. Define each of the following terms:

(a) genome -

(b) chromosomes -

(c) somatic cells -

(d) gamates -

(e) chromatin -

(f) mitosis -

(g) cytokinesis -

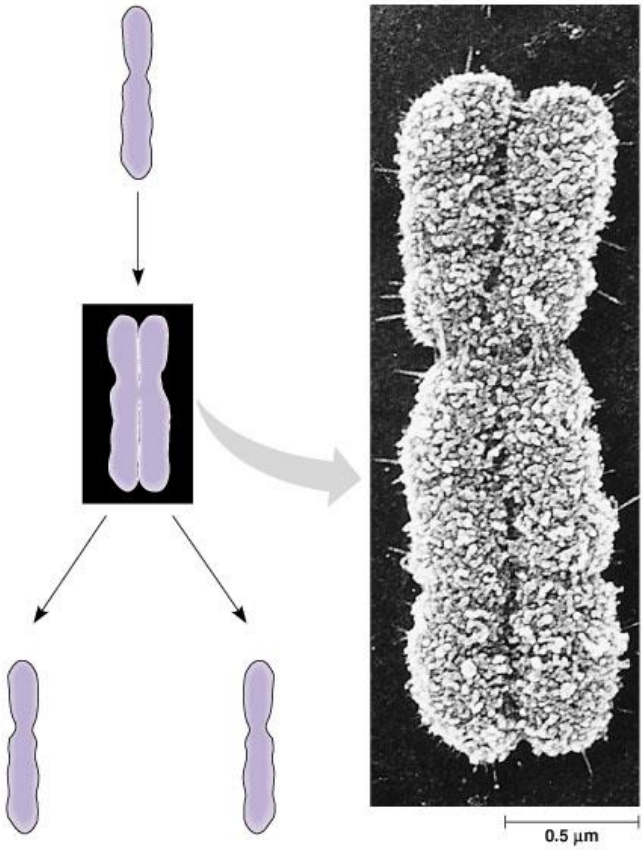
4. You are going to have to learn the difference between a number of similar-sounding terms. The diagram looks like an X represents a *replicated chromosome* that has two *sister chromatids*. The narrow "waist" represents the location of the *centromere*. Students often get all these terms confused,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

(a) chromosome -

(b) chromatid -

(c) centromere -

(d) chromatin -

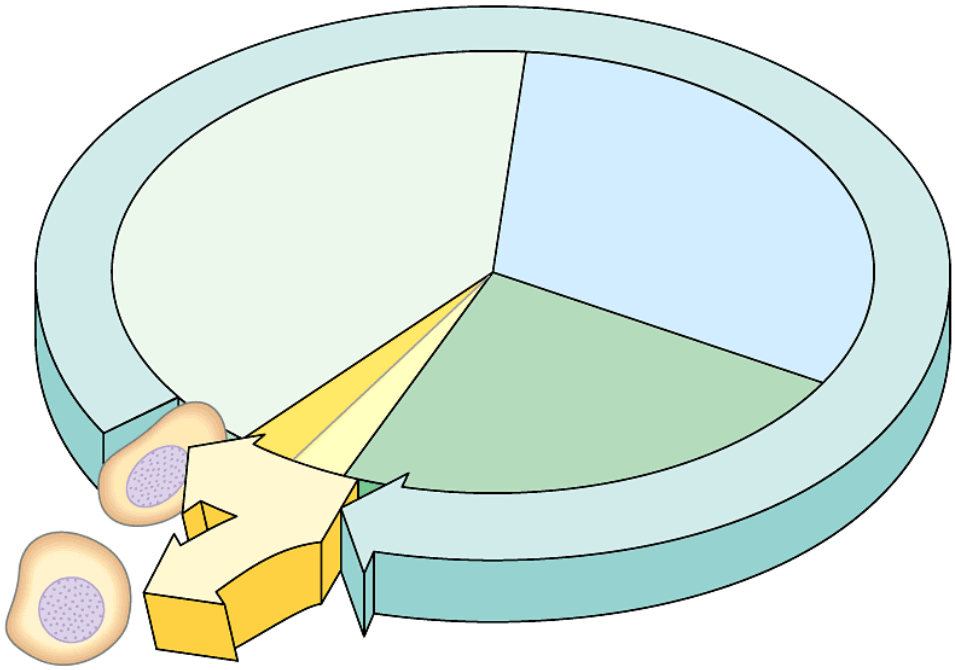


5. Describe what happens to the chromosome number as we follow the human life cycle through the generations.

6. What is the difference between ***mitosis*** and ***cytokinesis***?

The Mitotic Cell Cycle

7. Label the parts of the cell cycle listed below and give a brief explanation of what happens in each phase.



G_1 -

S -

G_2 -

Mitosis -

Cytokinesis -

8. How does interphase fit onto the cell cycle diagram on the previous page?

9. How does ***cytokinesis*** differ in animal cells and plant cells?

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

11. Notice that now you are learning a number of differences between prokaryotic and eukaryotic cells. Besides the fact that prokaryotes lack a membrane-bounded nucleus, do not undergo mRNA processing during transcription, describe each of the following differences:

(a) Mode of reproduction?

(b) Number of chromosomes?

(c) Shape of chromosome?

Regulation of the Cell Cycle

12. Do all cells go through the cell cycle at the same rate or at the same frequency? Explain.

13. What controls the cell cycle?

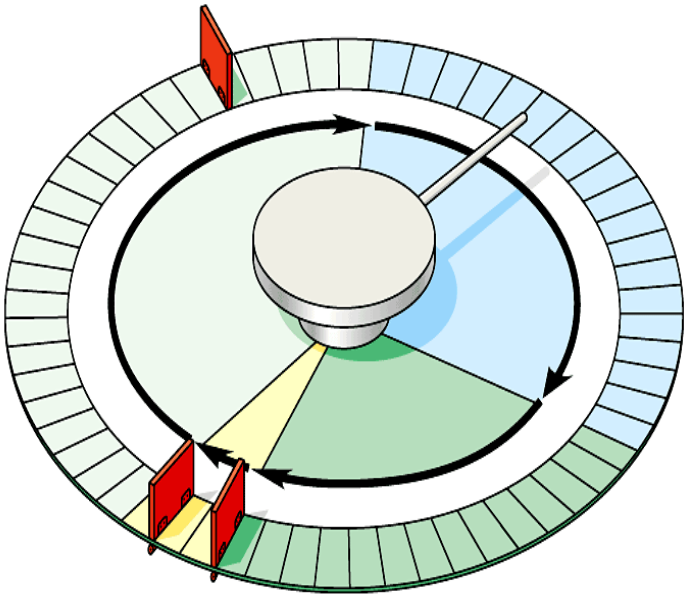
14. What is a cell cycle checkpoint?

15. Summarize what happens at each checkpoint and then label each in the diagram below. *(You may add to this as we discuss this in class.)*

(a) G_1 -

(b) G_2 -

(c) M -



16. What is meant by the G_0 phase? Describe this phase.

17. ***Kinases*** drive the cell cycle, but they must be activated by attachement of a _____.

18. The activity of ***cyclin-dependent kinases*** *(CDks)* rises and falls. Why?

19. What two things does **MPF** stand for and what does this molecule trigger?

20. What are ***growth factors***?

21. What is **PDGF** and how does it stimulate fibroblast division?

22. Cancer cells exhibit different behaviors than normal cells. Below are two normal behaviors they no longer show. Explain each behavior.

(a) density-dependent inhibition -

(b) anchorage dependence -

23. Cancer cells also show loss of cell cycle controls and may divide without being checked. The story of HeLa cells is worth noting. What is their source? How old are they?
(Note that, unlike normal cells, HeLa cells are immortal!)

24. What is ***transformation****?*

25. What is ***metastasis***?

26. Distinguish between a ***benign tumor*** and a ***malignant tumor***.

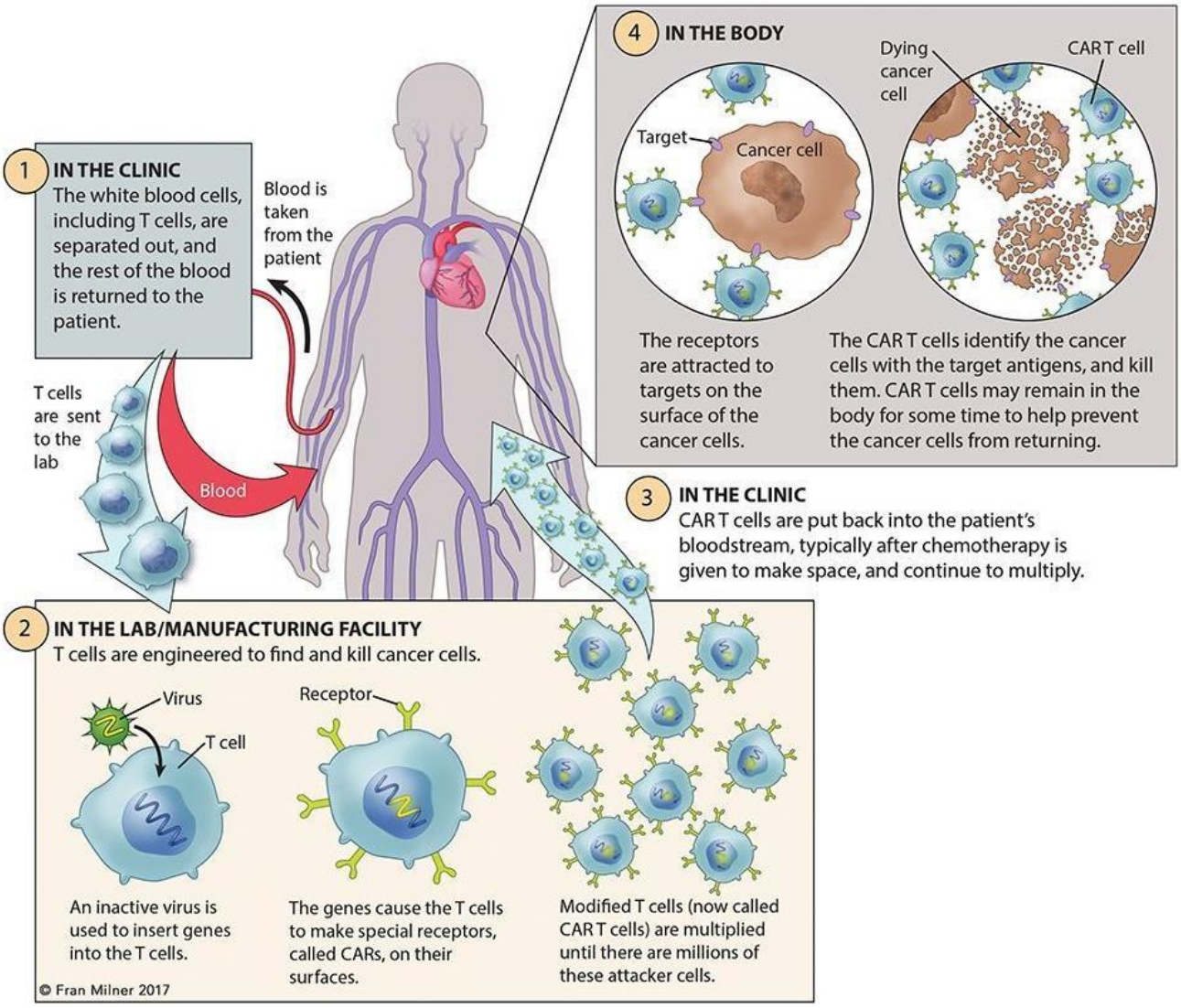
27. List two specific cancer treatments, and briefly describe how each treatment works.

28. Define immunotherapy?

29. What does CAR T-Cells stand for?

30. Define the term chimeric.

31. Use the diagram below to help you describe and explain CAR T-Cell Therapy.



Chapter 12: Summary of Key Concepts

THE KEY ROLES OF CELL DIVISION

- Cell division functions in reproduction, growth, and repair (p. 215, FIGURE 12.1) Unicellular organisms reproduce by cell division. Multicellular organisms depend on it for development from a fertilized egg, growth, and repair.
- Cell division distributes identical sets of chromosomes to daughter cells (pp. 216-217) Eukaryotic cell division consists of mitosis (division of the nucleus) and cytokinesis (division of the cytoplasm). DNA is partitioned among chromosomes, making it easier for the eukaryotic cell to replicate and distribute its huge amounts of DNA. Chromosomes consist of chromatin, a complex of DNA and protein that condenses during mitosis. When chromosomes replicate, they form identical sister chromatids. The chromatids separate during mitosis, becoming the chromosomes of the new daughter cells.

THE MITOTIC CELL CYCLE

- The mitotic phase alternates with interphase in the cell cycle: an overview (p. 217, FIGURES 12.4, 12.5) Mitosis and cytokinesis make up the M (mitotic) phase of the cell cycle. Between divisions, cells are in interphase: the G_1, S, and G_2 phases. The cell grows throughout interphase, but DNA is replicated only during the S (synthesis) phase. Mitosis is a continuous process, often described as occurring in five stages: prophase, prometaphase, metaphase, anaphase, and telophase.
- The mitotic spindle distributes chromosomes to daughter cells: a closer look (PP. 220-221, FIGURE 12.6) The mitotic spindle is an apparatus of microtubules that controls chromosome movement during mitosis. The spindle arises from the centrosomes, organelles near the nucleus that in animal cells include centrioles. Spindle microtubules attach to the kinetochores of chromatids and move the chromosomes to the metaphase plate. In anaphase, sister chromatids separate and move toward opposite poles of the cell. Using motor proteins, each kinetochore moves along shortening microtubules. Meanwhile, nonkinetochore microtubules from opposite poles slide past each other, elongating the cell. In telophase, daughter nuclei form at opposite ends of the cell.
- Cytokinesis divides the cytoplasm: a closer look (pp. 221-222, FIGURE 12.8) Mitosis is usually followed by cytokinesis, involving cleavage furrows in animals and cell plates in plants.
- Mitosis in eukaryotes may have evolved from binary fission in bacteria (pp. 223-224, FIGURES 12.10, 12.11) During binary fission, the two daughter bacterial chromosomes actively move apart by a mechanism that is not yet understood.

REGULATION OF THE CELL CYCLE

- A molecular control system drives the cell cycle (pp. 224-227, FIGURES 12.13-12.14) Cyclic changes in regulatory proteins work as a mitotic clock. The key molecules are cyclin dependent kinases, complexes of cyclins (whose concentrations build during the cell cycle) and specific protein kinases that are only active when combined with cyclin.
- Internal and external cues help regulate the cell cycle (pp. 227-228, FIGURE 12.15) Cell culture has enabled researchers to study the molecular details of cell division. Both internal signals, such as those emanating from kinetochores not yet attached to the spindle, and external signals, such as growth factors, control the cell cycle checkpoints via signal-transduction pathways. Growth factor depletion explains density-dependent inhibition.
- Cancer cells have escaped from cell cycle controls (p. 228-229, FIGURES 12.16, 12.17) Cancer cells elude normal regulation and divide out of control, forming tumors. Malignant tumors invade surrounding tissues and can metastasize, exporting cancer cells to other parts of the body.

Chapter 12 - Review Questions

__1) The creation of genetically identical offspring by a single parent, without the participation of sperm and egg, is called -
A) asexual reproduction.
B) sexual reproduction.
C) regeneration.
D) spontaneous generation.

__2) Which of the following statements regarding sexual and asexual reproduction is *true*?
A) Cell division only occurs after sexual reproduction.
B) Only offspring from asexual reproduction inherit traits from two parents.
C) Sexual reproduction typically includes the development of unfertilized eggs.
D) Sexual reproduction is more likely to increase genetic variation than is asexual reproduction.

__3) Asexual reproduction requires _____ individual(s).
A) 0 B) 1 C) 2 D) 3

__4) Which of the following statements regarding cell division is *false*?
A) Cell division can reproduce an entire organism.
B) Cell division is necessary for development to occur.
C) Cell division is the basis of both sexual and asexual reproduction.
D) Cell division is common in eukaryotes but rare in prokaryotes.

__5) Which of the following statements regarding prokaryotes is *false*?
A) Prokaryotic chromosomes are more complex than those of eukaryotes.
B) Most prokaryotes reproduce by binary fission.
C) Prokaryotic cells are generally smaller and simpler than eukaryotic cells.
D) In prokaryotes, daughter chromosomes are separated by an active movement away from each other and the growth of a new plasma membrane between them.

__6) It is difficult to observe individual chromosomes with a light microscope during interphase because -
A) the DNA has not been replicated yet.
B) they have uncoiled to form chromatin.
C) they leave the nucleus and are dispersed to other parts of the cell.
D) the spindle must move them to the metaphase plate before they become visible.

__7) Which of the following statements regarding the function of mitosis is *false*?
A) Mitosis allows organisms to grow.
B) Mitosis allows organisms to generate genetic diversity.
C) Mitosis allows organisms to reproduce asexually.
D) Mitosis allows organisms to repair tissues.

__8) Eukaryotic chromosomes differ from prokaryotic chromosomes in that they -
A) are simpler.
B) are circular in structure.
C) include fewer proteins.
D) are housed in a membrane-enclosed nucleus.

__9) Sister chromatids are -
A) found right after a cell divides.
B) joined together at a centromere.
C) made only of DNA.
D) unique to prokaryotes.

__10) Eukaryotic cells spend most of their cell cycle in which phase?
A) interphase B) prophase C) metaphase D) telophase

__11) Which of the following occurs during interphase?
A) a reduction in the size of the nuclear membrane
B) cytokinesis
C) cell growth and duplication of the chromosomes
D) separation of newly formed DNA to opposite ends of the cell

__12) The genetic material is duplicated during -
A) the mitotic phase. B) G_1. C) the S phase. D) G_2.

__13) The process by which the cytoplasm of a eukaryotic cell divides to produce two cells is called -
A) mitosis.
B) cytokinesis.
C) binary fission.
D) telophase.

__14) Looking into your microscope, you spot an unusual cell. Instead of the typical rounded cell shape, the cell has a very narrow middle separating two bulging ends. It sort of looks like the number 8! Then you realize that this cell is -
A) undergoing cytokinesis.
B) in the S phase of interphase.
C) in the G1 phase of interphase.
D) about to undergo mitosis.

__15) The phase of mitosis during which the mitotic spindle begins to form is -
A) interphase. B) prophase. C) metaphase. D) anaphase.

__16) During which phase of mitosis do the chromosomes line up on a plane equidistant from the two spindle poles?
A) prophase B) metaphase C) anaphase D) telophase

__17) At the start of mitotic anaphase, -
A) the centromeres of each chromosome come apart.
B) the chromatid DNA replicates.
C) nuclear envelopes begin to form around the chromosomes.
D) equivalent and complete collections of chromosomes have reached the two poles.

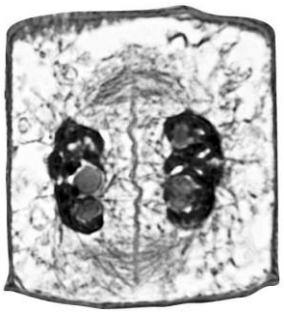
__18) During which phase of mitosis does the nuclear envelope re-form?
A) anaphase B) metaphase C) prophase D) telophase

__19) Which of the following is a feature of plant cell division that distinguishes it from animal cell division?
A) formation of a cell plate
B) formation of a cleavage furrow
C) lack of cytokinesis
D) production of four (rather than two) new cells per mitotic division

__20) Which of the following must occur for a plant or animal to grow and develop normally?
A) The organism must receive a supply of the appropriate hormones from its parents.
B) The organism must be able to control the timing and rate of cell division in different parts of its body.
C) Sufficient light must be available to stimulate cell division.
D) Sufficient oxygen must be available to stimulate cell division.

__21) When animal cells are grown in a petri dish, they typically stop dividing once they have formed a single, unbroken layer on the bottom of the dish. This arrest of division is an example of -
A) cell constraint.
B) density-dependent inhibition.
C) cell division repression.
D) growth factor desensitization.

__22) What type of cell is shown to the right?



A) animal cell in metaphase
B) animal cell in telophase
C) plant cell in metaphase
D) plant cell in telophase

__23) As a patch of scraped skin heals, the cells fill in the injured area but do not grow beyond that. This is an example of -
A) density-independent inhibition.
B) density-dependent inhibition.
C) anchorage independence.
D) growth factor inhibition.

__24) Which of the following is probably the main factor responsible for the phenomenon of density-dependent inhibition?
A) a local accumulation of growth-inhibiting factors
B) cells' innate ability to "sense" when the organ of which they are a part has no need for additional cells
C) a local deficiency of nutrients
D) physical contact of cell-surface proteins between adjacent cells.

__25) Which of the following statements regarding the cell-cycle control system is *false*?
A) The cell-cycle control system receives messages from outside the cell that influence cell division.
B) The cell-cycle control system triggers and controls major events in the cell cycle.
C) The cell-cycle control system includes three key checkpoints to complete a cell cycle.
D) The cell-cycle control system operates independently of the growth factors.

__26) Tissue culture experiments with PDGF demonstrate that without this substance -
A) bacterial cells lose their resistance to antibiotics.
B) cells divide in an uncontrolled fashion, confirming its role as a cell division inhibitor.
C) fibroblasts fail to divide.
D) the various kinases, such as MPF, are unable to bind to cyclin.

__27) You are asked to culture an unidentified sample of animal tissue. You notice that the cells seem to fail to exhibit density-dependent inhibition. The source of this tissue sample is most likely -
A) cancer tissue.
B) skin.
C) a fetal liver.
D) the sperm-producing tissue of the testis.

__28) A benign tumor differs from a malignant tumor in that a benign tumor -
A) is cancerous.
B) spreads from the original site.
C) does not metastasize.
D) never causes health problems.

__29) Which of the following shows the greatest promise as a cancer chemotherapy agent?
A) a drug that interferes with cellular respiration
B) a drug that prevents mitotic spindle from forming
C) a drug that prevents crossing over
D) a drug that prevents tetrad formation