

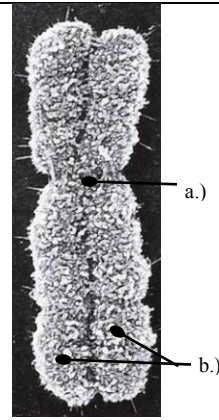
Active Learning Exercise 7. Cell Division: Mitosis and Meiosis

Reference: Chapters 12 &13 (*Biology* by Campbell/Reece, 8th ed.)

The Mitotic Cell Cycle (Reference: Chapter 12 (*Biology*, 8th ed.)

1. Cell division involves both **mitosis** and **cytokinesis**. Define mitosis and cytokinesis and state the important roles played by cell division.
2. The following questions deal with the organization of the genetic material within a cell. Make simple sketches to help you visualize the various structures as you answer these questions. Note: You may find [fig. 16.21 on page 320 \(Biology, 8th ed.\)](#) helpful when trying to visualize the packing, folding, and coiling of chromatin.
 - a.) What is **chromatin**?
 - b.) How is **chromatin** related to a chromosome?
 - c.) The length of a single chromosome is several thousand times the diameter of the cell containing it. How is it possible to fit such large structures into a cell?
 - d.) What are **sister chromatids**? What connects them?
3. Which of the following best describes the **kinetochore**?
 - a.) a structure composed of several proteins that associate with the centromere region of a chromosome and that can bind to spindle microtubules
 - b.) the centromere region of a metaphase chromosome at which the DNA can bind with spindle proteins
 - c.) the array of vesicles that will form between 2 dividing nuclei and give rise to the metaphase plate
 - d.) the ring of actin microfilaments that will cause the appearance of the cleavage furrow
 - e.) the core of proteins that forms the cell plate in a dividing plant cell

4. a.) Identify structures labeled in the electron micrograph of a duplicated chromosome to the right.
- b.) At what part of the cell cycle would you see a chromosome that looks like this? Give your reasons.



5. a.) Do all cells in your body have the same number of chromosomes? Explain.
- b.) Why **must** all sexually reproducing organisms have **both** mitosis and meiosis in their life cycles? What would be the consequence if sexually reproducing organisms had only mitosis?

6. Identify the **phases of the cell cycle** labeled in the diagram below and briefly indicate the major events that occur during each phase.

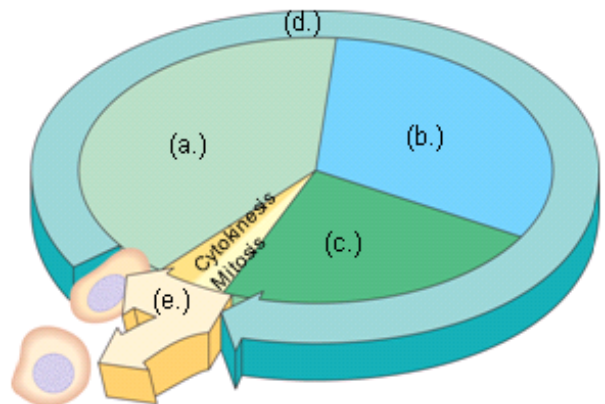
a.) Phase: _____

b.) Phase: _____

c.) Phase: _____

d.) Phase: _____

e.) Phase: _____



7. a.) Make a simplified diagram of *mitosis* and *cytokinesis* in an animal cell. Place **3 pairs** of chromosomes in your starting cell.
- Include and Label: prophase, prometaphase, metaphase, anaphase, telophase, cytokinesis, nuclear envelope, plasma membrane, fragments of nuclear membrane, centromere, kinetochore, spindle fibers/microtubules, duplicated chromosome, sister chromatids, daughter chromosomes, cleavage furrow.
- b.) What happens to the DNA during interphase (i.e. the S-phase of interphase) in preparation for mitosis?
- c.) How do the daughter cells compare genetically to the parent cell?
- d.) Where does mitosis occur in *your* body?

8. Why would an **oncologist** (a person studying tumors/cancer) be interested in the mechanisms of mitosis and the genetic controls involved in this process?
9. About a day after a human egg is fertilized by a sperm cell, the zygote (fertilized egg) divides mitotically for the first time, the two daughter cells usually stick together, and their repeated cell divisions give rise to a multicellular embryo. On rare occasions, however, the two daughter cells formed by the first division of the zygote separate. Each of these cells can go on to form a normal embryo—not a half-embryo or an otherwise defective embryo. Based on what you have learned about mitosis, explain why these “monozygotic twins” are essentially genetically identical.
10. **Vinblastine** is a drug that interferes with the assembly of microtubules. It is widely used for chemotherapy in treating cancer patients. Suggest a hypothesis to explain how vinblastine slows tumor growth.

Multiple Guess (Circle the letter of the correct response.)

11. Using the data in the table, the best conclusion concerning the difference between the S phases for beta and gamma is that...
- gamma contains more DNA than beta.
 - beta and gamma contain the same amount of DNA.
 - beta contains more RNA than gamma.
 - gamma contains 48 times more DNA and RNA than beta.
 - beta is a plant cell and gamma is an animal cell.

Minutes Spent in Cell Cycle Phases

Cell Type	G ₁	S	G ₂	M
Beta	18	24	12	16
Delta	100	0	0	0
Gamma	18	48	14	20

12. **Taxol** is an anticancer drug extracted from the Pacific yew tree. In animal cells, taxol disrupts microtubule formation by binding to microtubules and accelerating their assembly from the protein precursor, tubulin. Surprisingly, this stops mitosis. Specifically, taxol must affect
- the fibers of the mitotic spindle.
 - anaphase.
 - formation of the centrioles.
 - chromatid assembly.
 - the S phase of the cell cycle.

13. Measurements of the amount of DNA per nucleus were taken on a large number of cells from a growing fungus. The measured DNA levels ranged from 3 to 6 picograms per nucleus. In which stage of the cell cycle was the nucleus with 6 picograms of DNA?
a.) G_0 b.) G_1 c.) S d.) G_2 e.) M
14. A group of cells is assayed for DNA content immediately following mitosis and is found to have an average of 8 picograms of DNA per nucleus. Those cells would have _____ picograms at the end of the S phase and _____ picograms at the end of G_2 .
a.) 8 ... 8 b.) 8 ... 16 c.) 16 ... 8 d.) 16 ... 16 e.) 12 ... 16
15. A particular cell has half as much DNA as some of the other cells in a mitotically active tissue. The cell in question is most likely in
a.) G_1 . b.) G_2 . c.) prophase. d.) metaphase. e.) anaphase.
16. In some organisms, mitosis occurs without cytokinesis occurring. This will result in
a.) cells with more than one nucleus.
b.) cells that are unusually small.
c.) cells lacking nuclei.
d.) destruction of chromosomes.
e.) cell cycles lacking an S phase.
17. A cell in which of the following phases would have the least amount of DNA?
a.) G_0 b.) G_2 c.) prophase d.) metaphase e.) anaphase

Meiosis and Sexual Life Cycles (Reference: [Chapter 13](#))

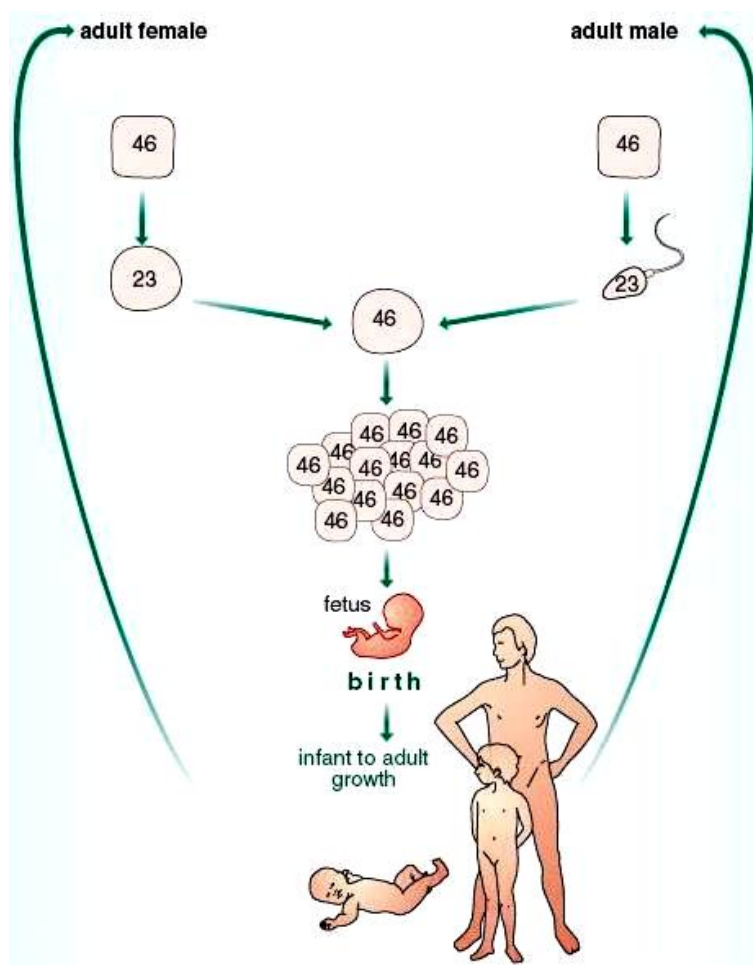
18. a.) What is ***asexual reproduction***? Give 2 examples—Include yourself (actually, a part of yourself!) as one of those examples.
- b.) How do the offspring compare genetically to the parent in these processes? Explain why.
19. How does ***sexual reproduction*** differ from ***asexual reproduction***? Explain in terms of the genetics of the offspring and the parents

20. Without **sexual reproduction** evolution would be extremely slow. Why?

21. a.) What is meant by **cell differentiation**? Hint: See the glossary and/or index for information for this one.

b.) Why is it important that differentiation occur during embryonic development in a multicellular organism?

22. Label each of the following in the diagram of the **human life cycle** below: mitosis, cellular differentiation, meiosis diploid cells, haploid cells, gametes, ovary, testis, sperm cell, egg cell, fertilization, zygote and where appropriate, (n) and (2n).



23. a.) Make a simplified diagram *meiosis* starting with a cell containing 3 pairs of chromosomes.
- Include and Label: Each stage of meiosis I & II and indicate if a cell is haploid (n) or diploid (2n); plasma membrane, centrosomes, nuclear envelope, sister chromatids, separation of sister chromatids, spindle fibers/microtubules, tetrad, chiasmata, crossing-over, homologous chromosomes, separation of homologous chromosomes, cleavage furrow.
- b.) What happens to the DNA during the interphase in preparation for meiosis?
- c.) What happens to the DNA during the interphase between meiosis I and II?
- d.) How do the daughter cells compare genetically to the parent cell after....
- i.) meiosis I?
 - ii.) meiosis II?
- e.) Is meiosis I or meiosis II (circle your choice) responsible for the production of haploid cells from diploid precursor cells?
- f.) What is the diploid number for the species that you diagramed? $2n = \underline{\hspace{2cm}}$
- The haploid number? $n = \underline{\hspace{2cm}}$

24. Compare and contrast mitosis and meiosis by completing the table below.

	Mitosis	Meiosis
Type of cells involved		
Number of cell divisions involved		
Number of daughter cells		
How do the daughter cells compare genetically?		
Are the daughter cells diploid (2n) or haploid (n)?		
Involves homologue pairing and cross over?		
Role played in organism		

25. Basic terminology you should know!! Define each in your own words and, whenever possible, use a small sketch/diagram as a memory aid.

a) Sex chromosome:

b) Autosome (or autosomal chromosome):

c) Synapsis:

d) Tetrad

e) Chiasma/chiasmata:

f) Crossing-over:

g) Haploid:

h) Diploid:

i) Homologous Chromosomes (homologues):

j) Gamete:

k) Somatic Cell:

26. a.) Does **cross over** occur during mitosis, meiosis or both? (circle your choice)

b.) At what stage of nuclear division does it occur? _____ What is its significance?

27. **Nondisjunction** is an error in meiosis or mitosis where homologous chromosomes or sister chromatids do not separate from each other. Down syndrome is a human genetic disease where individuals have an extra chromosome 21, giving them a total of 47 chromosomes. They suffer from mental retardation, heart and respiratory disease, will die prematurely, and invariably have Alzheimer's disease later in life. Use your knowledge of mitosis and/or meiosis to hypothesize how nondisjunction results in Down syndrome.

Multiple Guess (Circle the letter of the correct response.)

28. The DNA content of a diploid cell in the G_1 **phase** of the cell cycle is measured. If the DNA content is x , then the DNA content of the same cell at **metaphase of meiosis I** would be...
- a.) $0.25x$ b.) $0.5x$ c.) x d.) $2x$ e.) $4x$.
29. The DNA content of a diploid cell in the G_1 **phase** of the cell cycle is measured. If the DNA content is x , then the DNA content at **metaphase of meiosis II** would be...
- a.) $0.25x$ b.) $0.5x$ c.) x d.) $2x$ e.) $4x$.
30. Which of the following would not be considered a **haploid cell**?
- a.) daughter cell after meiosis II
b.) gamete
c.) daughter cell after mitosis in gametophyte generation of a plant
d.) cell in prophase I
e.) cell in prophase II
31. The DNA content of a cell is measured in the G_2 **phase**. After **meiosis I**, the DNA content of one of the two cells produced would be...
- a.) equal to that of the G_2 cell.
b.) twice that of the G_2 cell.
c.) one-half that of the G_2 cell.
d.) one-fourth that of the G_2 cell.
e.) impossible to estimate due to independent assortment of homologous chromosomes.
32. How do cells at the completion of meiosis compare with cells that have replicated their DNA and are just about to begin meiosis?
- a.) They have twice the amount of cytoplasm and half the amount of DNA.
b.) They have half the number of chromosomes and half the amount of DNA.
c.) They have the same number of chromosomes and half the amount of DNA.
d.) They have half the number of chromosomes and one-fourth the amount of DNA.
e.) They have half the amount of cytoplasm and twice the amount of DNA.
33. Two **sister chromatids** are joined at the centromere prior to mitosis.
- a.) These chromatids make up a diploid chromosome.
b.) These chromatids make up a haploid chromosome.
c.) The two sister chromatids were formed by DNA replication of a single chromatid
d.) The cell that contains these sister chromatids must be diploid.
e.) The cell that contains these sister chromatids must be haploid.