

PROGRESSIONS:
PEER-LED TEAM LEARNING

Module 9: The Life Cycle of Eukaryotic Cells

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I. Introduction

Eukaryotic cells (with membrane-bound nuclei) reproduce themselves and have **life cycles** including “birth”, maturation and reproduction, and cell death. For single cells, the process of reproduction is called **cell division**. One **parent cell** divides, giving rise to two identical **daughter cells**. Cell division actually includes two processes, **mitosis** and **cytokinesis**. The first divides up the **chromosomal** material of the nucleus; the second partitions the **cytoplasm** into two separate compartments. In healthy cells division is regulated closely by a number of mechanisms that insure orderly processes of reproduction, growth and repair. Understanding cell division as a segment of the cell life cycle is the general objective of this laboratory.

Benchmarks. These statements indicate what you should be able to do to demonstrate your mastery of the biology content and skills in this module having completed this workshop.

1. Represent by drawing and labeling, the genetic material of a diploid cell.
2. Explain with words and diagrams the events in each phase of the cell life cycle focusing on changes in the genetic material.
3. Draw an interphase cell and cells in the four phases of mitosis, explaining the processes occurring in each phase.
4. Use correct biological terms to explain genetic structure and cell division.
5. Relate elements of cell genetic structure and cell division to one another through concept mapping and other methods.
6. Describe the roles of cell division in reproduction, replacement and repair of body tissues, and disease.
7. Compare mitosis in animal and plant cell.
8. Identify the control mechanisms for cell reproduction and briefly state how they work.

Prepare for your workshop by reading your textbook (Campbell, 4th Edition, Chapter 11; Audesirk, et al., 6th Edition, Chapter 11) and completing the Pre-Workshop activities below. Show your work on the pages of this handout.

II. Pre-Workshop Activities

Activity 1. Genetic material in the cell

1. Label Figure 9.1 using the following terms.
 - a. chromosome
 - b. gene
 - c. gene locus
 - d. allele
 - e. homologous chromosomes
 - f. nucleus
 - g. cytoplasm
 - h. cell membrane.

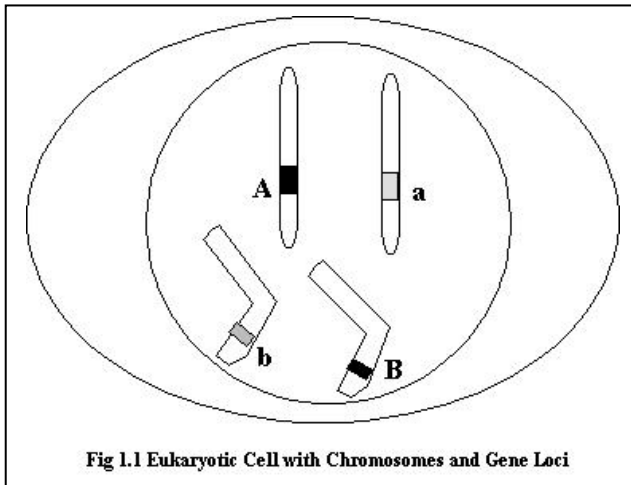


Figure 9.1. Eukaryotic Cell with Chromosomes and Gene Loci

2. Fix the diagram. Referring back to Fig. 9.1, modify the drawing so that the cell appears as it would in prophase of mitosis. Now define the following terms & use them to label the redrawn Fig. 9.1.
 - a. centromere
 - b. sister chromatids
 - c. single chromosome
 - d. double chromosome
 - e. centrosome
 - f. mitotic spindle

3. In Fig 9.1 add another gene to each chromosome pair and label them **S** and **T**.

Activity 2. Cell Division & Life Cycle

1. a. Arrange the following in correct sequence using the format of a flow chart: anaphase, metaphase, telophase, prophase, interphase, mitosis, cytokinesis, G-2 phase, G-1 phase, and S phase.
2. The sequence you represented is called what?

Activity 3. Vocabulary Review

Use your text readings and lecture notes to review the following vocabulary terms related to the Cell Life Cycle. Be ready to give a brief definition for each.

life cycle	cell division	parent cell
daughter cells	mitosis	cytokinesis
eukaryotic cells	nucleus	chromosome
chromatids (sister)	centromere	double chromosome
gene	interphase	prophase
metaphase	anaphase	telophase
G-1 phase	S phase	G-2 phase
mitotic spindle	cell cycle	single chromosome
DNA strand	zygote	egg, sperm
cell reproduction	cytoplasm	apoptosis
kinetocor	centrosome	binary fission
regulators of cell cycling		

Activity 4. Control of Cell Cycles

1. When a cell is late in the G1 phase, it may proceed in two different directions. Name the subsequent phases it may enter and explain each.
2. The following factors can regulate the timing of transitions from one phase of the cell cycle to the next. Indicate briefly what each does.
 - a. protein kinases
 - b. cyclins
 - c. cell size
 - d. growth factors

III. Workshop Activities

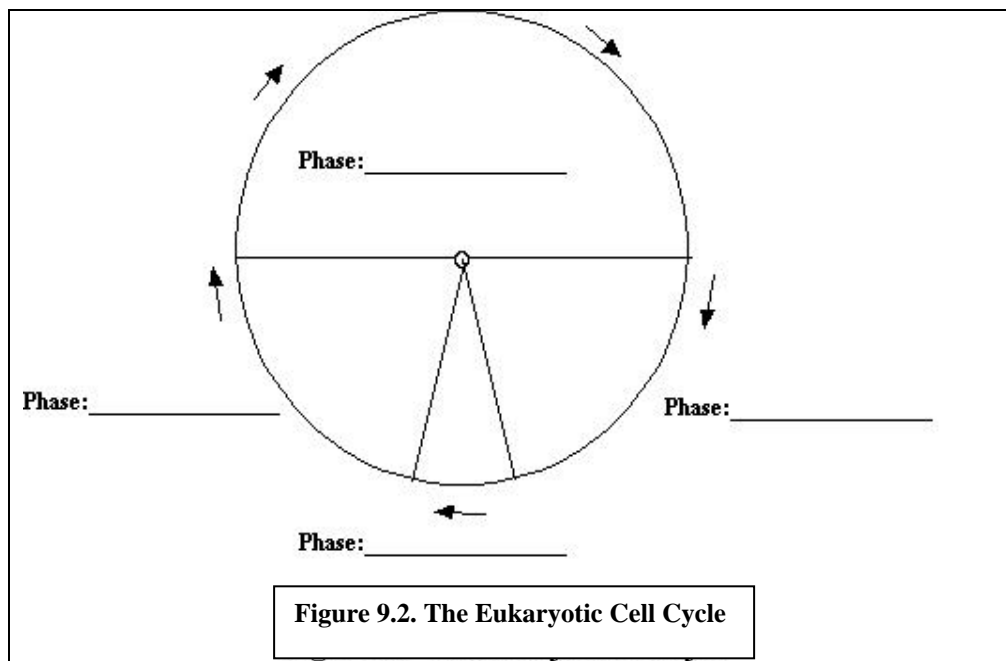
Activity 1. Review of Pre-Workshop Activities

Pair critique/group discussion. Organize the workshop into pairs of students or teams of three. Within the pair/team, students do a round-robin to review answers to questions identified by the peer leader. If students get different answers or are unable to answer a question, the item should be raised in the group discussion that follows.

Activity 2. The Cell Cycle and Mitosis

Round-robin. After a student provides an answer, the next student in sequence is asked to a) comment on the prior answer, and b) give the next answer in the sequence.

1. Represent the following events in the cell life cycle as a flow diagram. Remember you are representing a cycle. Events: **mitosis, cell division, cytokinesis, G1, G2, and S phases.**
2. Pie Chart Summary. Use the flow diagram to complete the pie chart (Fig 9.2) below and for each event, note the important changes that occur in it.



3. Complete Table 9.1. Focus on the main events indicated by the column headings. Each student takes one cell in the round robin.

Table 9.1 Phases of Cell Division

Phase	Chromosome appearance & location	Important events
1 Prophase		
2 Metaphase		
3 Anaphase		
4 Telophase		
5 Cytokinesis		

Activity 3. Evaluate the definitions

Divide the workshop into two teams. The competition is to complete the five items below before the other team. When one team is finished, the peer leader calls “Time” and has that team give their corrections. The second team may then identify errors or differences in their results. The peer leader identifies the winning team or indicates a draw. For the definitions in # 1 - 5, circle any items that are incorrect and change the words to make them correct. Write TRUE if all the information is already correct.

1. *Mitosis*: the same as *cell division*; can be divided into four *phases*; usually produces two *daughter cells* which are genetically identical; an important process for *wound healing* and *tumor growth* in cancer.
2. *Chromosome*: made up of *DNA* in long strands; tightly coiled and visible during *cell division*; segments along it are called *genes*; double for most of the cell's life but single, briefly, in the period before *mitosis* begins.
3. *Homologous chromosomes*: have *loci* for particular *genes* are found at the same positions; make up a *chromosome pair*; one goes to each *daughter cell* in *mitotic divisions*.
4. *Cell cycle*: starts with the "*birth*" of a new cell as a result of *cell division*; ends when a cell divides; longest portion is *mitosis*; *interphase* includes 4 distinct periods; some body cells may stop in the *G-1 phase* and not continue the cycle.
5. *G-2 Phase*: part of *mitosis*; comes before the *S phase*; cell organizes itself for the next *cell division*; cycle is arrested in this stage if no further divisions will occur; **G** stands for *growth*.

Activity 4. Animal and Plant Cell Mitosis

1. Give a title to each cell in the Figure 9.3 that indicates its phase in mitosis.
2. Arrange the figures in correct order by giving them numbers, starting with #1 for interphase.
3. Label the following items on one or more of the cells: **nucleus, cell wall, spindle, cell plate, chromosomes, cytoplasm, and metaphase plate.**

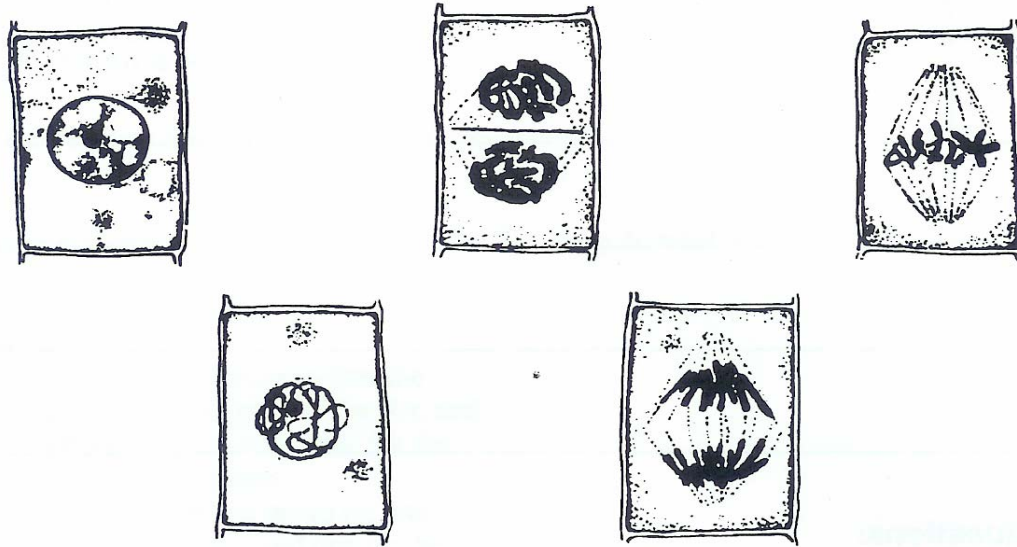


Fig. 9.3. Life Cycle of a Plant Cell.

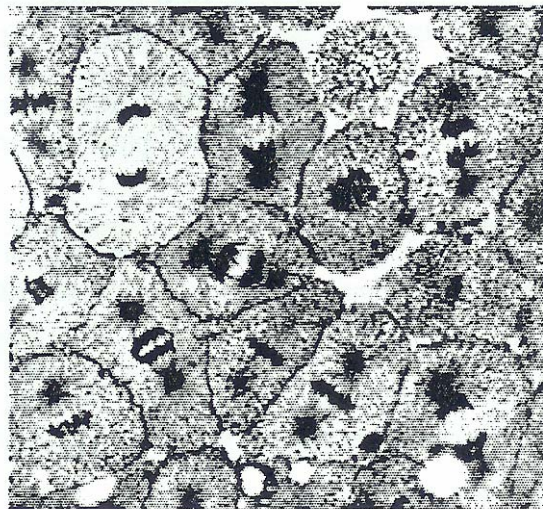


Fig. 9.4. Animal Cell Mitosis


- a. Label Figure 9.4 with the following terms: **anaphase, metaphase, prophase, telophase, interphase, and cytokinesis.**
- b. How could one tell by looking that these are animal cells?

5. a. What is the most common phase of mitosis based upon this figure?
 b. What is the least common phase?
 c. Suggest why there are differences in frequency of phases? All divisions include all phases.
6. a. With what phase of mitosis does cytokinesis overlap? _____
 b. What does cytokinesis accomplish? _____
7. Compare mitosis in animal and plant cells.
 - a. What are the similarities?
 - b. What are the differences?
 - c. How could you determine by looking through a microscope if cytokinesis is going on in a plant cell? In an animal cell?

Activity 5. Concept Mapping

Your leader will review briefly the skill of concept mapping at the beginning of this activity.

Relationships. Do this section as a round robin. State one or more relationships between each pair of terms below by preparing a simple concept map. One is done as an example. Other students may add or correct answers of those coming before them.

- overlaps with
- __1. mitosis and cytokinesis: 
- __2. daughter cells and parent cell
- __3. prophase and metaphase
- __4. telophase and cytokinesis
- __5. S phase and chromosomes
- __6. metaphase and anaphase
- __7. anaphase and telophase
- __8. G₁ and G₀
- __9. S phase and mitosis

Small concept families. Do this section in pairs and put your map on the blackboard or a large sheet of newsprint to share with other groups. Together the italicized words in each definition of Activity 4 above form groups called concept families. The central concept is the item being defined. For each item organize the central concept and the italicized words of the definition into a concept map. Be sure to use the rules for concept mapping learned earlier.

Larger concept families. Two teams should be organized to do this section. Develop concept maps for the following concept families. The central concept is the first one. You may add additional concepts to your map. Put the maps on a blackboard or large piece of paper for sharing with the other team.

- __1. *chromosome*: gene, gene locus, homologous pair, double chromosome, single chromosome, interphase, prophase, anaphase, metaphase, telophase.

__2. *cell division*: homologous chromosomes, life cycle, daughter cells, sister chromatids, metaphase, spindle, cell reproduction, mitosis, nucleus, centromere, anaphase, cytokinesis, chromosome, double chromosome, prophase, telophase, single chromosome.

Activity 7. Mitosis summary

Jigsaw. Divide into three groups. Each is responsible for one column in Table 9.2. Work for 3-5 minutes getting your information together. The entire workshop reconvenes and the answers are entered on a table on the board in round robin fashion by members of the team. It may be helpful for each team to draw a cell on the board in the phase it is working with.

Table 9.2 Mitosis summary

Stage	Parent Cell in G-1 Phase	Parent Cell after S Phase	Daughter Cell after Mitosis
No. of chromosomes			
Single or double?			
No. of chromatids			
No. of homologous pairs			
Haploid or diploid cell?			

Activity 8. Regulation of Cell Cycling

Do this as a round robin.

1. Explain how each of the following influence cell cycling:
 - a. growth factors (ex. Platelet derived growth factor)
 - b. density of cells in a tissue
 - c. protein kinases
 - d. cyclins
 - e. maturation promoting factor
 - f. feedback destruction of cyclins

2. Show some known relationships between the factors above by drawing a flow chart that includes them and the stages of a cell life cycle. The first student puts two terms on the board and connects them with a labeled flow arrow. The second student may add another term on either side of the first.

IV. Post-Workshop Activities

The following exercises are provided for you to complete after the workshop. They allow you to test your own mastery of the material separate from the collaborative work done in the meeting. They afford extra practice with the skills and ways of thinking about the material used in the workshops.

Activity 1. The Cell Life Cycle

1. a. Compare the amount of DNA in a cell prior to and after the S phase.

- b. How is the DNA organized at these times?

2. Compare the size of the cell at the beginning of G-1 and near the end of G-2. What accounts for the difference?
3. a. G-1, S, and G-2 together make up what phase or period in the cell cycle?
b. Is it true that the cell is resting during this period? Explain.
4. Compare the two sister chromatids of one double chromosome.

Activity 2. Check on Mastery

Matching. For each of the numbered statements, match a term from the following list.

- | | | |
|--------------|------------------|----------------|
| a. anaphase | b. cell division | c. cytokinesis |
| d. G-1 phase | e. G-2 phase | f. interphase |
| g. metaphase | h. mitosis | i. prophase |
| j. S phase | k. telophase | |

1. The nuclear membrane breaks down.
2. Chromosomes align near the cell equator.
3. The cell grows in size.
4. The cell's DNA is replicated.
5. Single chromosomes migrate to opposite poles of the dividing cell.
6. The chromosomes coil tightly and become visible.
7. A new nuclear membrane forms.
8. Cleavage furrows appear at the equator of the parent cell.
9. The centromere between sister chromatids breaks.
10. A period in which the cell does not divide.
11. A series of four stages in which the genetic material in the nucleus is divided into two.

Activity 3. Relationships

State one or more relationships between each pair of terms below by preparing a simple concept map.

1. centromeres and chromatids
2. chromatids and chromosomes

3. gene locus and gene
4. gene and chromosome
5. two homologous chromosomes
6. mitotic spindle and chromosome migration

Activity 4. Concept Maps

Develop concept maps for the following concept families. The central concept is the first one. You may add additional concepts to the map.

1. Genotype (of a cell): heterozygous, homozygous, genome, allele, and gene.
2. Genetic makeup of a cell: heterozygous, homozygous, genotype, genome, diploid, allele, homologous chromosomes, DNA strand, nucleus, chromosome, double chromosome, and single chromosome.
3. Cell life cycle: homologous chromosomes, daughter cells, chromatids, metaphase, G-1 phase, cell reproduction, cell division, mitosis, nucleus, interphase, anaphase, S phase, parent cell, cytokinesis, chromosome, double chromosome, prophase, telophase, G-2 phase, single chromosome, apoptosis.

Activity 5. Diagramming. Without looking at your book or notes diagram cells in each stage of mitosis and label them using the following terms: prophase, metaphase, anaphase, telophase, mitotic spindle, nuclear membrane, centrosome, centromere, double chromosome, sister chromatid, chromosome migration, poles of a dividing cell, daughter cells, cytokinesis.

Progressions: Peer-Led Team Learning
The Workshop Project Newsletter
Fall 2005, Volume 7, Issue 1

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This newsletter is supported by a grant from the National Science Foundation's Division of Undergraduate Education. The views expressed herein do not necessarily represent those of the National Science Foundation.