

## Cell Cycle and Mitosis

### THE CELL CYCLE

The **cell cycle**, or **cell-division cycle**, is the series of events that take place in a **eukaryotic cell** between its formation and the moment it replicates itself. These events can be divided in **two** main parts: **interphase** (*in between divisions* phase grouping **G<sub>1</sub> phase**, **S phase**, **G<sub>2</sub> phase**), during which the cell is forming and carries on with its normal metabolic functions; the **mitotic phase** (M mitosis), during which the cell is replicating itself. Thus, cell-division cycle is an essential process by which a single-cell fertilized egg develops into a mature organism and the process by which hair, skin, blood cells, and some internal organs are formed.

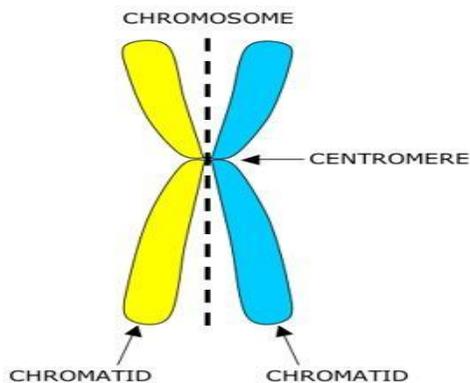
1. What is meant by the cell cycle or cell division cycle?
2. In what type of cells --- prokaryotes or eukaryotes --- does the cell cycle occur?
3. Name the 2 main PHASES of the cell cycle.
4. \_\_\_\_\_ is in between the times when a cell is dividing.
5. What is occurring in a cell during interphase?
6. What is occurring during the mitosis phase?
7. A fertilized cell develops into a \_\_\_\_\_ organism during the cell cycle.
8. Name three things that form during the cycle.

### INTERPHASE

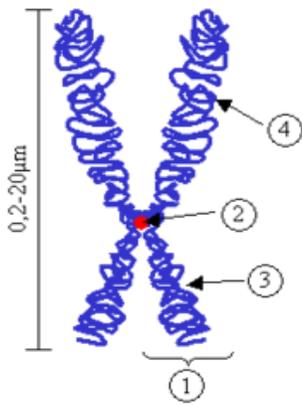
**Interphase** is a phase of the cell cycle, defined only by the absence of cell division. During interphase, the cell **obtains nutrients**, and **duplicates (copies) its chromatids** (genetic material). The genetic material or chromatids are located in **the nucleus** of the cell and are made of the **molecule DNA**.

9. What process NEVER occurs in interphase?
10. Cells obtain \_\_\_\_\_ and duplicate or copy their \_\_\_\_\_ or genetic material during interphase.
11. Where are chromatids found in a cell?
12. Chromatids are made of a molecule called \_\_\_\_\_.

Chromatids are connected by the **centromere** and have a **LONG AND SHORT ARM**.



**Label** the parts of the chromosome including the long and short arms.



1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

Most eukaryotic cells spend most of their time in interphase. For example, human skin cells, which divide about once a day, spend roughly 22 hours in interphase. About 90 percent of cells are in interphase. Some cells, such as nerve cells, can stay in interphase for decades. There are 3 parts of interphase: **G<sub>1</sub>** (growth 1 in which the cell creates organelles and begins metabolism), **S phase** (DNA synthesis in which the chromosomes of the cell are copied) and **G<sub>2</sub>** (growth 2 in which the cell grows in preparation for cell division). **Find the cell cycle drawing** on this worksheet and **draw an additional line in red** around those parts of the cell cycle diagram that are included in interphase.

13. In what PHASE do most cells spend the majority of their lifetime?

14. How often do human skin cells divide each day?

15. How many hours per day is a human skin cell in interphase?

16. What type of cell may spend decades in interphase instead of dividing?

17. Name the 3 stages in interphase.

18. What does **G<sub>1</sub>** stand for and what occurs in this stage? What does **S** stand for and what occurs in this stage?

19. What does  $G_2$  stand for and what occurs in this stage?

Sometimes the cells exit the cell cycle (usually from  $G_1$  phase) and enter the  **$G_0$  phase**. In the  $G_0$  phase, **cells are alive and metabolically active**, but do not divide. In this phase cells do not copy their DNA and do not prepare for cell division. Many cells in the human body, including those in **heart muscle, eyes, and brain** are in the  $G_0$  phase. **If these cells are damaged they cannot be replaced**. Again find the cell cycle drawing on this worksheet and **draw an arrow in black** on the cell cycle showing where a cell would enter the  $G_0$  phase.

20. From stage of the cell cycle do cells sometimes EXIT?

21. What happens to cells that enter the  $G_0$  stage?

22. Name 3 types of cells that enter the  $G_0$  phase when they are mature?

23. What happens if these cells are damaged during your lifetime?

The  **$G_1$  phase** is a period in the cell cycle during interphase, after **cytokinesis** (process whereby a single cell is divided into two identical daughter cells whenever the **cytoplasm** is divided) and before the S phase. For many cells, this phase is the major period of **cell growth** during its lifespan. During this stage **new organelles are being synthesized (made)**, so the cell requires both structural proteins and enzymes, resulting in great amount of protein synthesis. **Color the  $G_1$  phase green** on the cell cycle drawing.

24. What stage occurs after cytokinesis?

25. What part of the cell is divided during cytokinesis?

26. What are the new cells called and how do they compare with each other?
27. What is major thing happening to a cell during  $G_1$ ?
28. What cell structures are made in  $G_1$ ?
29. Since proteins and \_\_\_\_\_ are being made during  $G_1$ , there is a great amount of protein \_\_\_\_\_ occurring.

The **S phase**, short for **synthesis phase**, is a period in the cell cycle during interphase, **between  $G_1$  phase and the  $G_2$  phase**. Following  $G_1$ , the cell enters the S stage, when **DNA synthesis or replication** occurs. At the beginning of the S stage, each chromosome is composed of one coiled **DNA double helix** molecule, which is called a chromatid. At the end of this stage, each chromosome has two identical DNA double helix molecules, and therefore is composed of **two sister chromatids**. During S phase, the centrosome is also duplicated. **Color the S phase orange.**

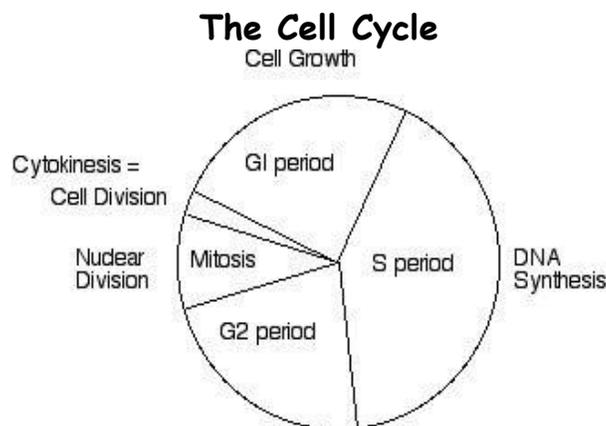
30. What does the S phase stand for?
31. What happens during the S phase?
32. Each chromosome originally is made of how many DNA molecules and how does this molecule appear in the chromosome?
33. At the end of S phase each chromosome has how many coiled DNA molecules?
34. What structure holds the duplicated chromosomes together and is also copied during the S phase?

**$G_2$  phase** is the third, final, and usually the **shortest subphase** during interphase within the cell cycle in which the **cell undergoes a period of rapid growth to prepare for mitosis**. It follows successful completion of

DNA synthesis and chromosomal replication during the S phase, and occurs during a period of often four to five hours. Although chromosomes have been replicated they cannot yet be distinguished individually because they are still in the form of loosely packed **chromatin fibers**. The  $G_2$  phase continues growth of the cell and prepares the cell for mitosis (M phase) by producing all of the enzymes that the cell will need in order to divide. **Color the  $G_2$  phase light blue.**

After the  $G_2$  phase of interphase, the **cell is ready to start dividing**. The **nucleus and nuclear material** (chromosomes made of DNA) divide first during stage known as **MITOSIS**. Mitosis is also called **KARYOKINESIS** (*karyon* means nucleus) because only the nucleus is dividing. **Color the Mitosis stage purple.**

35. What is the final and shortest phase of interphase?
36. About how long would a typical cell be in the  $G_2$  phase?
37. How is the cell prepared for mitosis during the  $G_2$  phase?
38. What follows the  $G_2$  phase?
39. What part of the cell is actually dividing in mitosis?
40. What is another name for mitosis?



## **MITOSIS (KARYOKINESIS) - NUCLEAR DIVISION**

**Mitosis** is the process in which a **eukaryotic cell** (cell containing a nucleus) separates its already **duplicated chromosomes** (copied during the S phase) into **two sets** of chromosomes so there will be **two identical nuclei**. It is generally followed by **cytokinesis** which divides the cytoplasm and cell membrane. *Color the Cytokinesis stage yellow.* This results in **two identical cells** (both have an identical set of chromosomes) with an equal distribution of organelles and other cellular components. The **mitotic (M) phase** and **cytokinesis (C phase)** together are called **cell division**, the division of the **parent cell** (original) into **two daughter cells** (new cells), each with the same **genetic information (chromosomes) as the parent cell**. Mitosis **does NOT occur in prokaryotic cells** that do **NOT** have a nucleus. In multicellular organisms, the **somatic cells** (body cells) undergo mitosis, while **germ cells** — cells destined to become sperm in males or ova (eggs) in females — divide by a related process called **meiosis**. **Prokaryotic cells** (bacteria), which lack a nucleus, divide by a process called **binary fission**.

41. When are chromosomes duplicated --- before or during mitosis?
42. What process follows mitosis?
43. The nucleus is divided during \_\_\_\_\_, while cytoplasm of the cell is divided during \_\_\_\_\_.
44. How do the two new cells compare with each other?
45. The two new cells are called \_\_\_\_\_ cells.
46. Does mitosis occur in prokaryotes? Explain why or why not.
47. What process is used by bacteria to divide and reproduce?
48. Body cells are called \_\_\_\_\_ cells, while reproductive cells are known as \_\_\_\_\_ cells.

The process of **mitosis (division of the nucleus)** is divided into **four stages (Prophase, Metaphase, Anaphase, and Telophase)**. Immediately

following nuclear division (mitosis), the **cell membrane** must also divide (**cytokinesis**). Animal cells divide the cytoplasm by constricting the cell membrane in the middle to form a **cleavage furrow**. Plant cells form a **cell plate** in the center to divide the cytoplasm. At Interphase, there is only one cell, but after cytokinesis there are two identical cells.

49. Name the 4 mitotic stages.
50. How does cytokinesis occur in an animal cell?
51. How does cytokinesis occur in a plant cell?

During interphase, the genetic material is called **chromatin** and can NOT be clearly seen because it isn't tightly coiled. When **prophase begins**, the DNA molecules are progressively shortened and condensed by coiling, to form visible **chromosomes**. **Enzymes** during prophase break down the **nuclear membrane and nucleolus** so they are no longer visible. Spindle fibers also form in prophase which will attach to the chromosomes. At **metaphase**, the spindle fibers attach themselves to the **centromeres** of the chromosomes and align the chromosomes at the **equator** (middle of the cell). **Anaphase** is the next stage. The spindle fibers shorten and the centromere splits separating the two sister chromatids. During **telophase**, the chromosomes pairs (chromatids are pulled to opposite poles of the cell. The **nuclear envelope and nucleolus reform** before the **chromosomes uncoil**. The **spindle fibers disintegrate**.

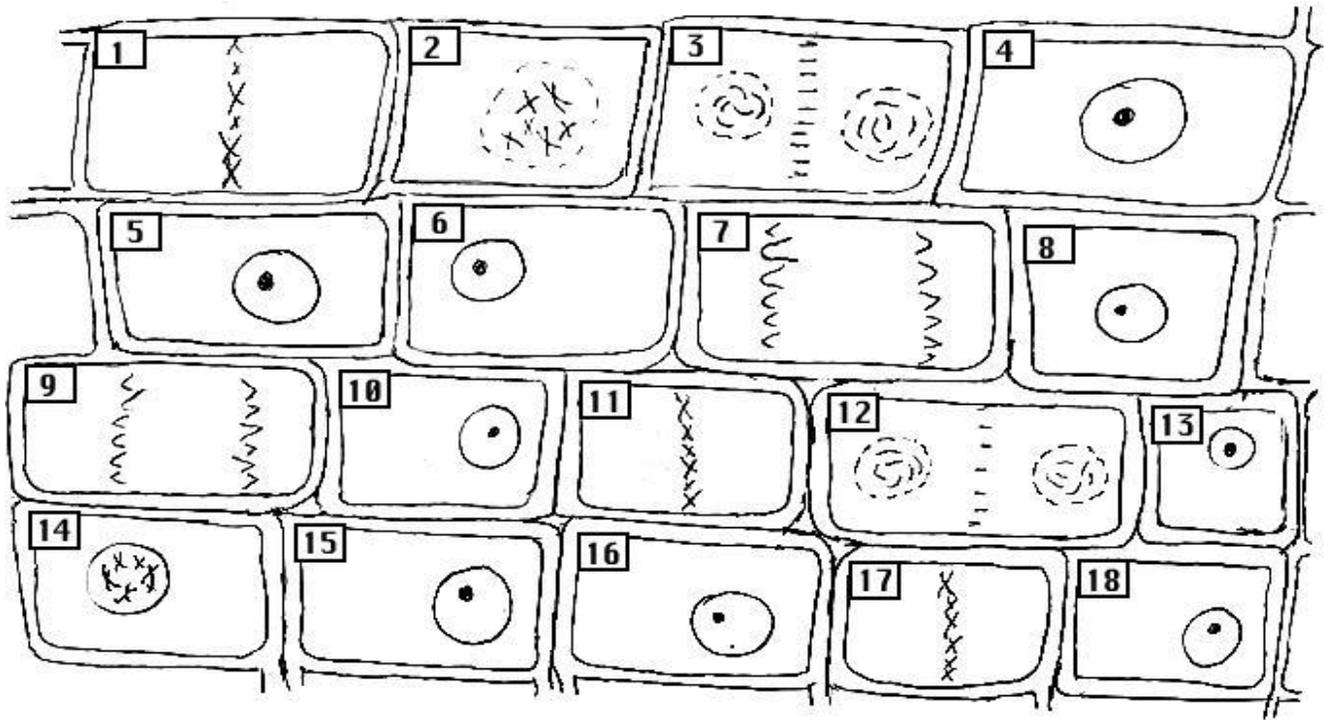
52. Genetic material is called \_\_\_\_\_ during interphase and **IS / IS NOT** clearly visible.
53. What makes the chromosomes become visible during prophase?
54. What is used to help break down the nuclear membrane?
55. Besides the nucleus, what else is broken down during prophase?

56. What forms during prophase to LATER attach and move chromosomes?
57. Doubled chromosomes are held together by the \_\_\_\_.
58. Where do chromosomes line up during metaphase?
59. During what stage are sister chromatids separated and moved to opposite ends of the cell?
60. Name 4 things that happen during telophase.
  - a.
  - b.
  - c.
  - d.

***Name each numbered stage in the plant cell cycle diagram:  
(interphase, prophase, metaphase, anaphase, or telophase)***

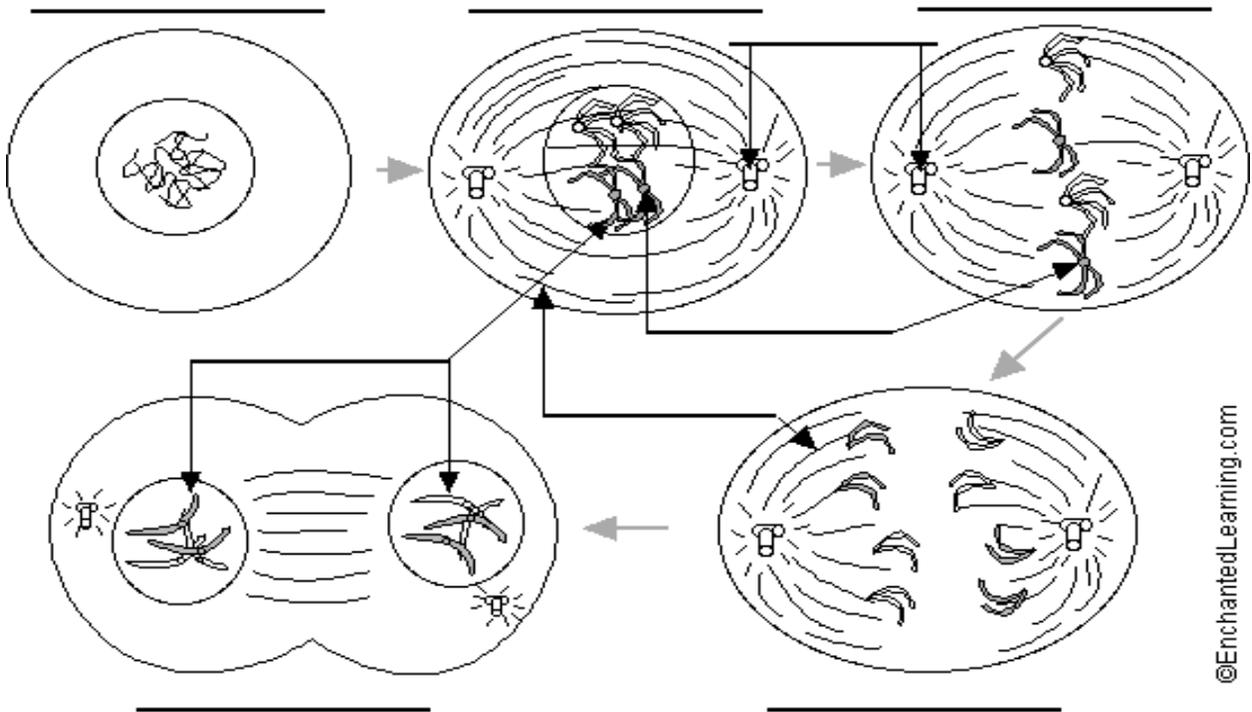
- |           |            |            |
|-----------|------------|------------|
| <b>1.</b> | <b>7.</b>  | <b>13.</b> |
| <b>2.</b> | <b>8.</b>  | <b>14.</b> |
| <b>3.</b> | <b>9.</b>  | <b>15.</b> |
| <b>4.</b> | <b>10.</b> | <b>16.</b> |
| <b>5.</b> | <b>11.</b> | <b>17.</b> |
| <b>6.</b> | <b>12.</b> | <b>18.</b> |

## **Plant Cells in Mitosis**



**Label the stages of the cell cycle & mitosis. LABEL and COLOR the stages in the plant cell and animal cell. The stages should be colored as follows --- interphase-pink, prophase-light green, metaphase-red, anaphase-light blue, and telophase-yellow. Also label the CENTRIOLES, SPINDLE FIBERS, CENTROMERE, and CHROMOSOMES.**

# Mitosis of an Animal Cell



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