2.4 The Cell Cycle

At this very moment, there are millions of cells undergoing cell division inside your body. But what about the rest of the trillions of cells in your body? What are they doing? Cells are not always dividing. The **cell cycle** is the sequence of events in the cell from one cell division to another (Figure 1). Just as you are growing and carrying out the normal functions of a human, most of the cells in your body are also growing in size or carrying out their normal functions. For example, muscle cells are using energy to contract. The cells that line your small intestine are absorbing nutrients from your digested food. This phase of growing and working is called **interphase**. A cell is in interphase for 90 % of the total time of the cell cycle. During interphase, the cell makes copies of each organelle in the cytoplasm. Once the cell is large enough, it will also make a copy of, or replicate, its chromosomes. Each chromosome and its copy are known as **sister chromatids**. Each sister chromatid carries identical instructions for the functions of the cell. Interphase and cell division make up the cell cycle.

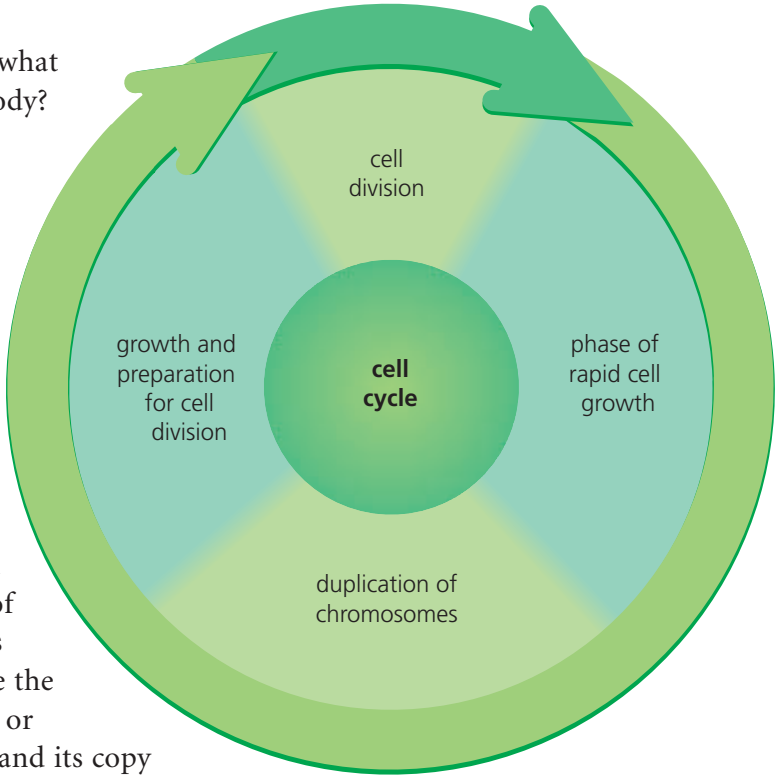


Figure 1 The circle represents the cell cycle of a eukaryotic cell. The light arrow represents the time the cell spends in interphase and the dark arrow represents the time in cell division. The labels indicate what is happening in the cell as the cycle progresses.

Cell Division

Even though different cells have different functions, the process of cell division is extremely similar in all cells and in all organisms. In both the unicellular paramecium and the giant blue whale, for example, one cell (called the **parent cell**) divides into two genetically identical cells (called **daughter cells**). The main difference is that the paramecia daughter cells become two separate organisms, while the blue whale daughter cells continue to divide and stay interconnected to make up the cells of various tissues and organs.

Cell division is composed of two processes: mitosis and cytokinesis. **Mitosis** is the process that divides the nuclear material. **Cytokinesis** is the process that divides the cytoplasm and the rest of the organelles in half. Cytokinesis usually begins before mitosis is finished. Each daughter cell receives approximately half the cytoplasm and organelles, and will be about half the size of the parent cell.

Did You KNOW?

Suicide Cells

Certain cells are genetically programmed to die after a certain number of cell divisions. For example, the eyelids of newborn puppies form an unbroken layer of skin. Shortly after birth, the eyelid cells across the middle of the eye die, allowing the top and bottom eyelids to separate and the eyes to open.

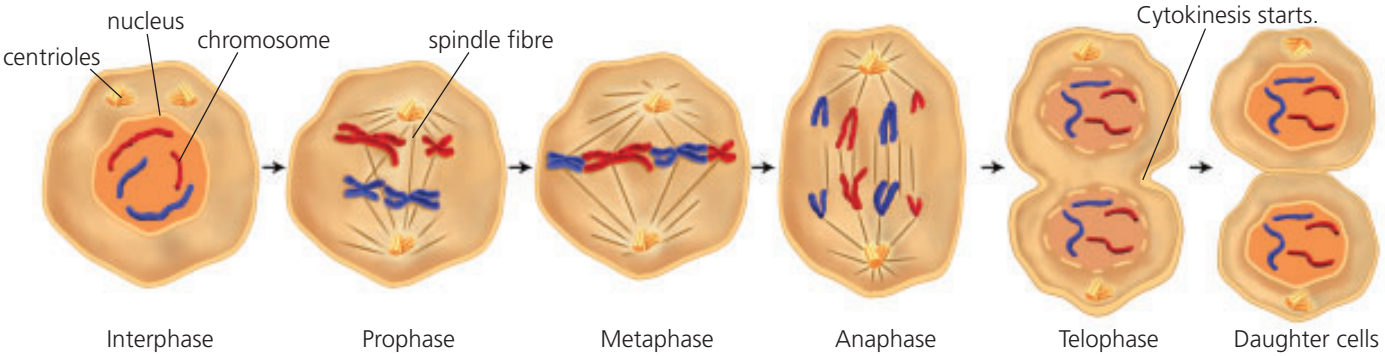


Figure 2 Mitosis and cytokinesis in an animal cell

If you would like to learn more about mitosis, go to **www.science.nelson.com** GO

The Stages of Mitosis

Mitosis is a continuous process, but, to make it easier to describe, we divide it into four stages: prophase, metaphase, anaphase, and telophase. Figure 2 shows the stages of mitosis and the process of cytokinesis in an animal cell. GO

1. Prophase

The first stage of mitosis is **prophase**. The sister chromatids that were formed during interphase have shortened and thickened, and are now visible with a light microscope. The sister chromatids become joined at or near the centre and look like an X (Figure 3). The nucleolus is no longer visible. The nuclear membrane breaks down and the chromosomes spread out in the cytoplasm. In animal cells, the centrioles, which were replicated during interphase, move to opposite poles of the cell and start to form spindle fibres. Spindle fibres are microtubules that grow toward the centre of the cell. The spindle fibres form the **spindle**, which moves the chromatids during the later stages of cell division.

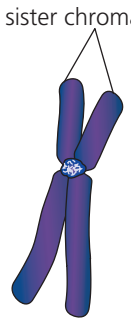


Figure 3 A single duplicated chromosome is made of two sister chromatids joined at or near the centre.

2. Metaphase

The second stage of mitosis is **metaphase**. The spindle is completely formed, and the sister chromatids attach to the spindle fibres. The sister chromatids line up along the middle of the cell, halfway between the poles of the cell.

3. Anaphase

Anaphase is the third stage of mitosis. In anaphase, the sister chromatids are pulled apart by the spindle and move toward the opposite poles of the cell. The chromatids are now called chromosomes again.

4. Telophase

The last stage of mitosis is **telophase**. The new chromosomes have reached the opposite poles of the cell. During telophase, the events of prophase happen in reverse: two nuclear membranes form, the spindle disappears, the chromosomes lengthen and get thinner, and the nucleoli reappear. Mitosis is now complete. The original nucleus has divided into two genetically identical nuclei. 2A *Investigation*

2A *Investigation*

Observing Cell Division in Plant and Animal Cells

To perform this investigation, turn to page 64.

In this investigation, you will look at onion root tip and whitefish embryo cells under a microscope to observe the stages of cell division.

Cytokinesis

Cytokinesis is the second process in cell division. It begins at the end of mitosis, during telophase. Cytokinesis divides the cytoplasm into two daughter cells. It is visible in animal cells by an indentation or pinching of the cell membrane and cytoplasm between the two new nuclei. The new daughter cells are now in interphase.

Cytokinesis is different in plant cells and animal cells. In plant cells, there is no indentation in the cell membrane. Membrane-bound vesicles form between the two nuclei (Figure 4). The vesicles fuse together to form the cell plate. The cell plate grows outward toward the cell membrane, forming a new cell membrane for each daughter cell, as well as the cell wall between the two new membranes. 2B • *Investigation*

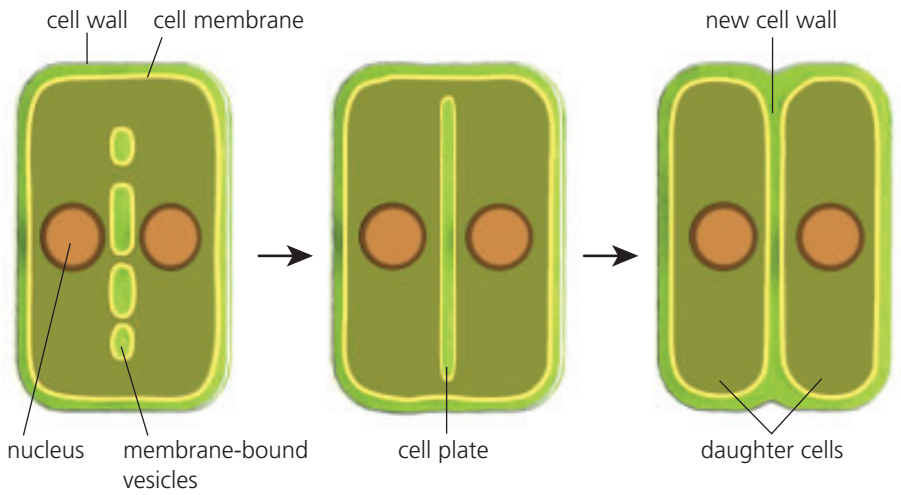


Figure 4 In plant cell cytokinesis, the cell plate forms new cell membranes and a new cell wall between the daughter cells.

LEARNING TIP

Making study notes is important for learning and remembering. Read this section again, and look at the headings. Turn each heading into a question, and then read to answer it. Record your answers in point form under each heading.

2B • *Investigation*

Determining the Rate of Cell Division in Plants and Animals

To perform this investigation, turn to page 66.

In this investigation, you will take another look at an onion root tip and a whitefish embryo under a microscope to determine the percentage of cells that are dividing. You will use what you learn to make a cell division clock.

TRY THIS: A Model of Cell Division

Skills Focus: creating models, observing, communicating

Materials: craft materials, such as modelling clay, pipe cleaners, wool, twist ties, string, rubber bands, and paper clips

This activity is intended to help you understand the continuous process of cell division.

1. Work with a partner to build a model of a cell. Your model must allow the chromosomes to be moved to show the stages of mitosis.
2. Your model must also be large enough to allow the chromosomes to move to the opposite poles of the cell.

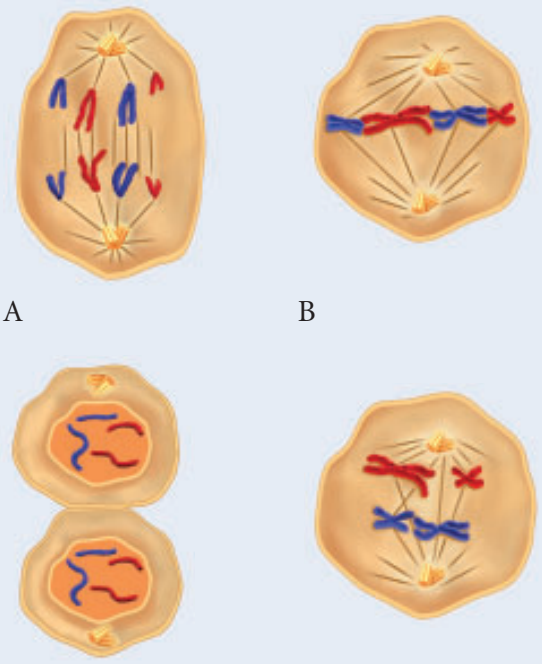
A. What event has to happen before mitosis begins? When does this event happen? What are the structures called now?

B. At each stage of mitosis, stop and describe to your partner what is happening.

C. Rearrange your cell model to show both animal cytokinesis and plant cytokinesis. Describe to your partner how each is different.

2.4 CHECK YOUR Understanding

1. What are the stages of the cell cycle?
2. When does the cell cycle start? When does it end?
3. Approximately what percentage of the cell cycle is interphase?
4. What event must occur before mitosis can begin?
5. How do the daughter cells compare with the parent cell?
6. What stage are the daughter cells in immediately following cell division?
7. A normal human body cell has 46 chromosomes. After mitosis, how many chromosomes should be in each daughter cell?
8. Identify the stages of mitosis, labelled A to D, in Figure 5.



A B C D

Figure 5

9. (a) List the stages of mitosis in their correct order.
   (b) Describe one feature that identifies each stage of mitosis.
10. Why is it necesary for a cell to duplicate its nuclear material?
11. What is the duplicated nuclear material called?
12. Why is telophase sometimes described as reverse prophase?
13. Use a table to compare and contrast cytokinesis in an animal cell with cytokinesis in a plant cell.
14. A human red blood cell has no chromosomes. How does this affect the red blood cell's ability to divide?
15. Interphase used to be described as a "resting stage." Explain why this is inaccurate.
16. No nuclei are found in the cells of the outermost layer of your skin. A company claims that its moisturizer can restore and rejuvenate these cells.
   (a) Would these skin cells be capable of producing other skin cells? Explain why or why not.
   (b) Evaluate the company's claim.
17. (a) Identify the dividing cells in Figure 6 as plant or animal cells.
   (b) Which of the processes involved in cell division is happening in each of the cells?

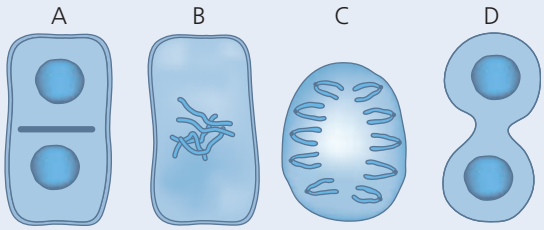


Figure 6