Duration: 100 min | Undergraduate | Food Science & Technology | UNS

The Cell-Division Cycle

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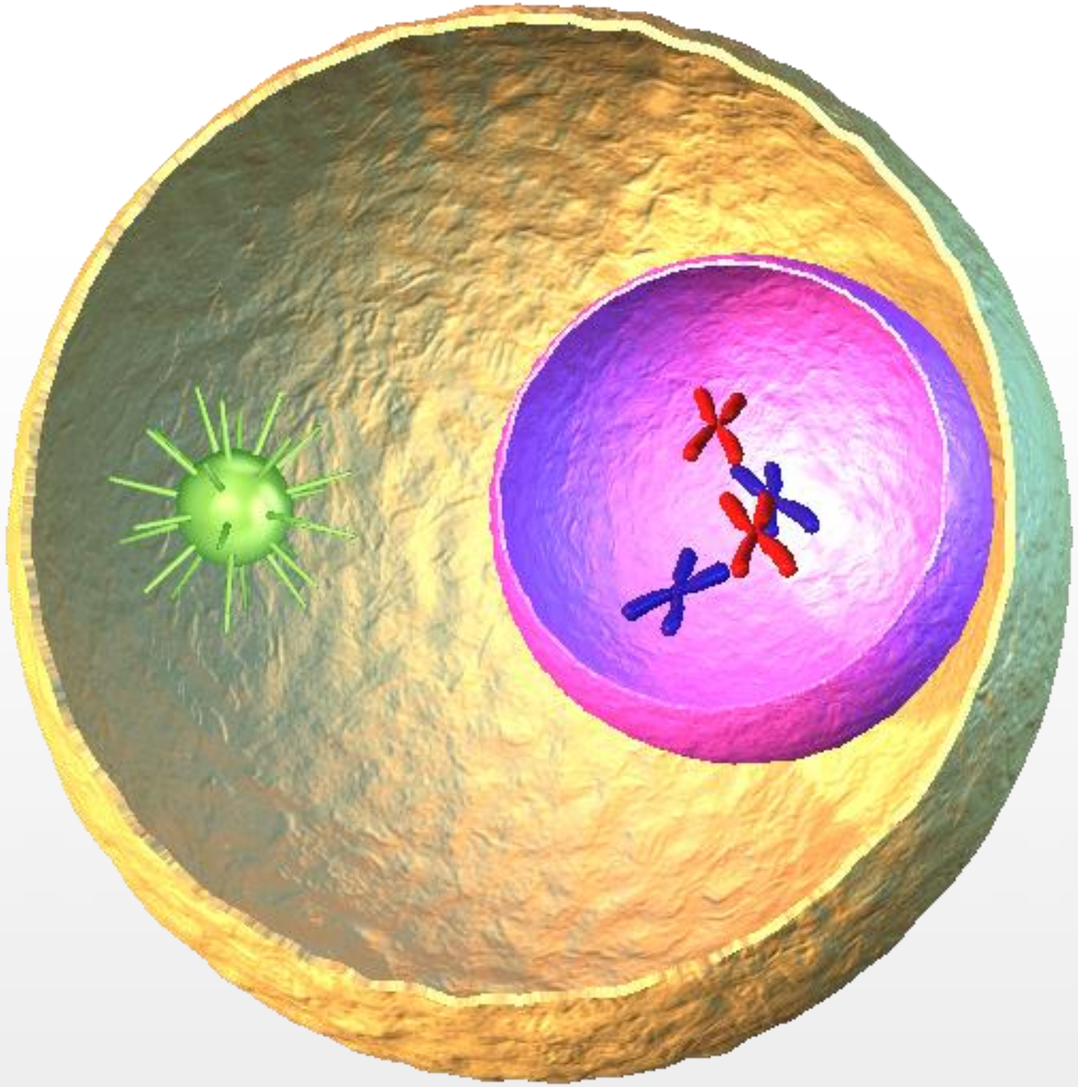
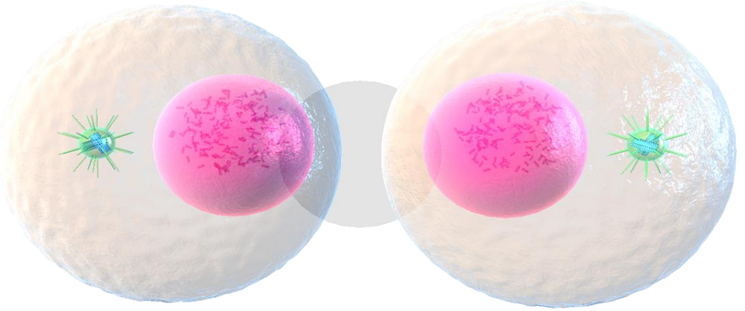




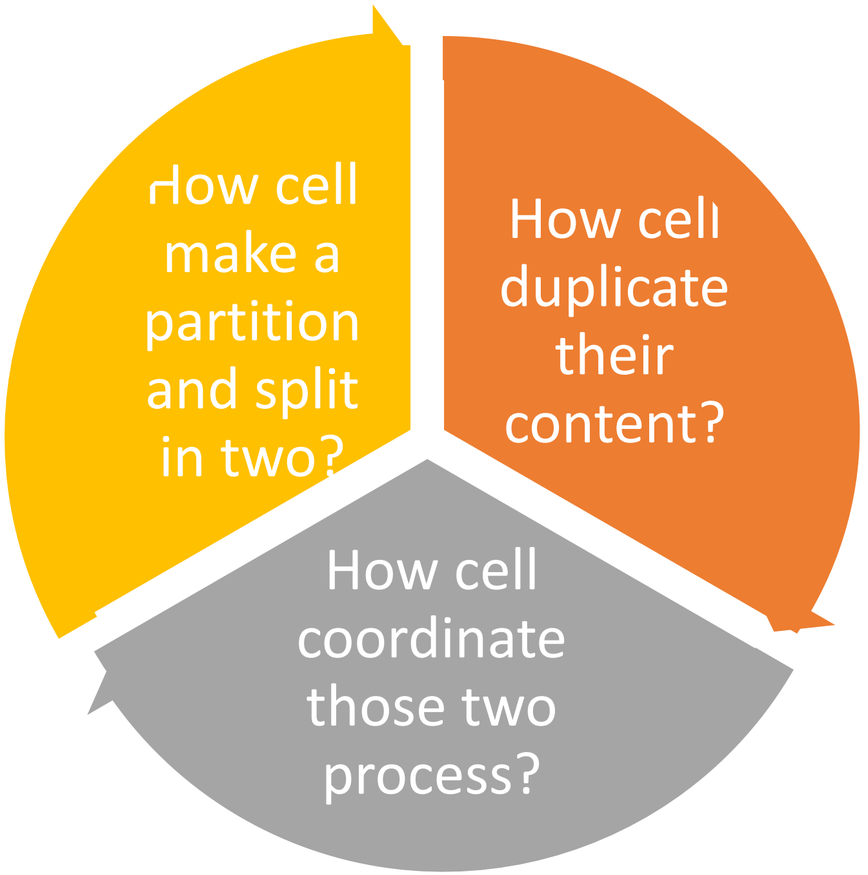
Lesson overview

- “Where a cell arises, there must be a previous cell, just as animals can only arise from animals and plants from plants.” (Statement in chapter book written by Rudolf Virchow ,1858)
- A cell reproduces by carrying out an orderly sequence of events in which it duplicates its contents and then divides in two → **known as the cell cycle**, is the essential mechanism by which all living things reproduce.
- In this chapter we will discuss about how cell reproduce

Learning outcome

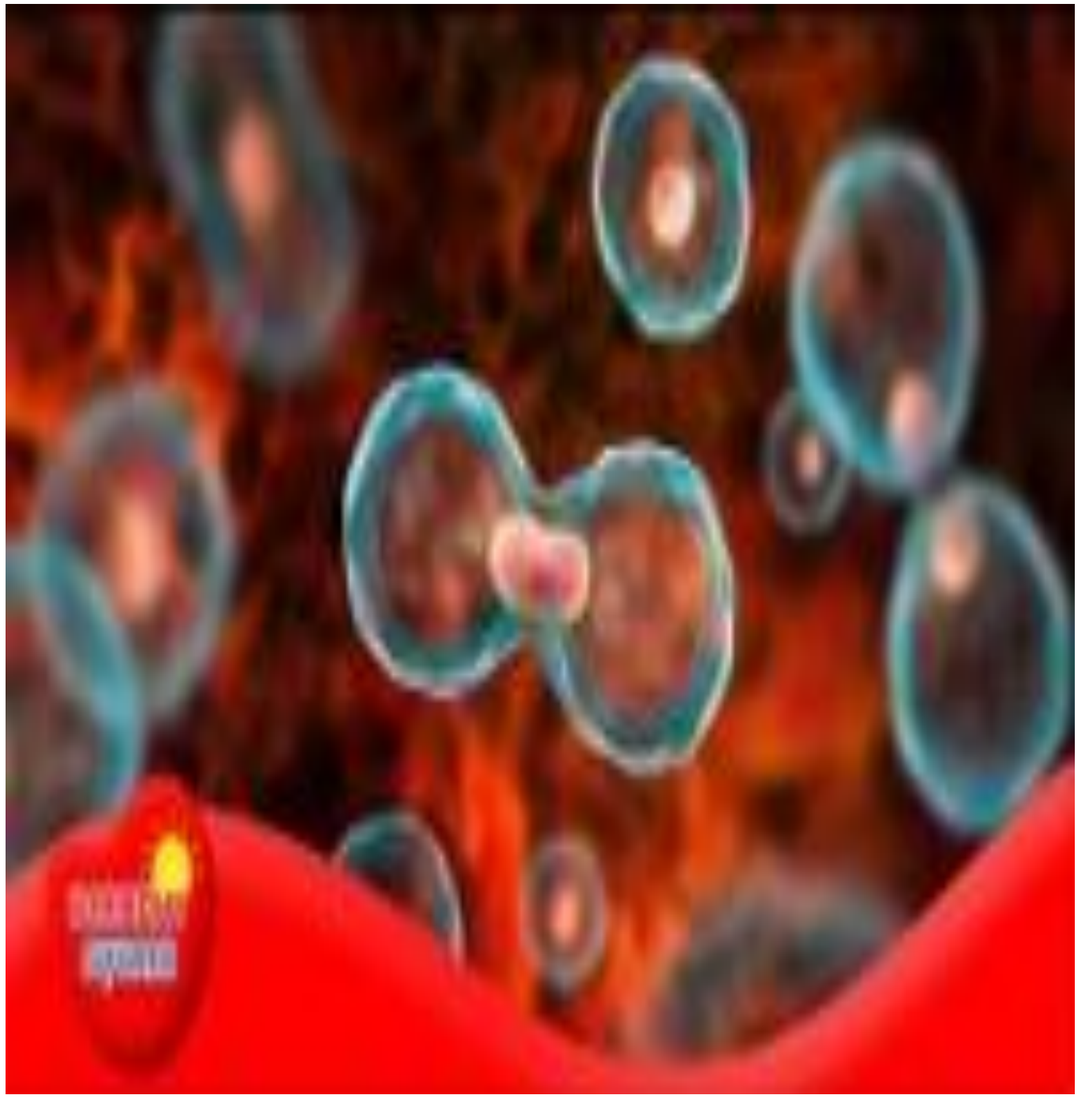
- Define the cell-cycle and how the cell control this mechanism
- Identify the phase of the cell-cycle
- Define asexual reproduction (mitosis) and name its phases
- Define sexual reproduction (mitosis) and name its phases

How Cell Reproduces?



Cell Division in Procaryotes

- In prokaryotes, cell division consists of a simple procedure called **binary fission** in which the cell divides into two equal or nearly equal halves
- The genetic information is replicate by DNA-replication mechanism
- The “daughter” genomes are attached side-by-side to the plasma membrane.
- As this process proceeds, the cell lays down new plasma membrane and cell wall materials in the zone between the attachment sites of the two daughter genomes.
- A new plasma membrane grows between the genomes; eventually, it reaches all the way into the center of the cell, dividing it in two.



The Cell-Cycle

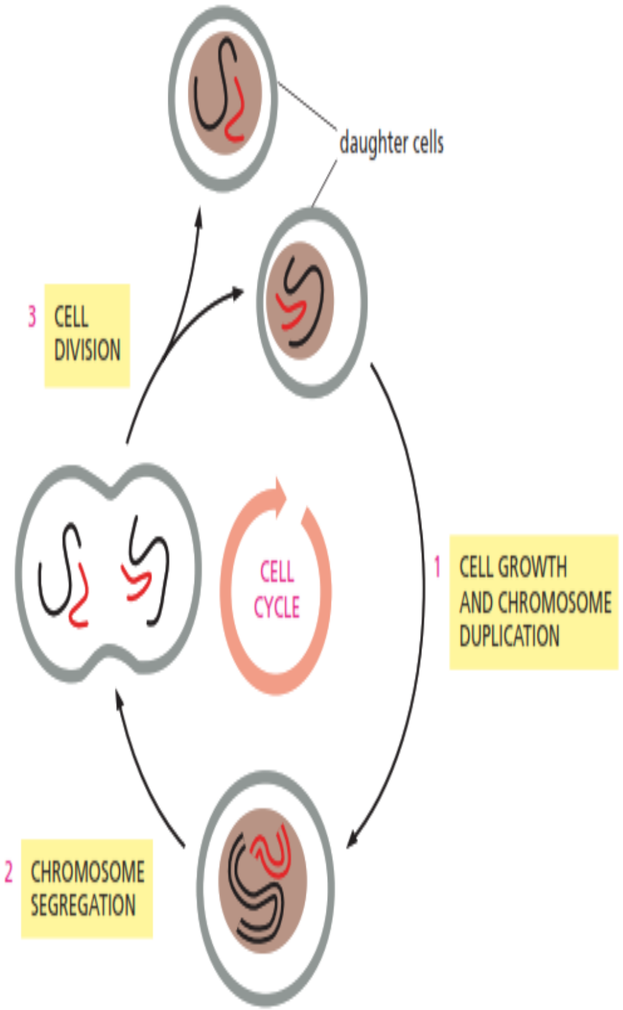


Figure 18–1 Cells reproduce by duplicating their contents and dividing in two, a process called the cell cycle. For simplicity, we use a hypothetical eukaryotic cell—with only one copy each of two different chromosomes—to illustrate how each cell cycle produces two genetically identical daughter cells. Each daughter cell can divide again by going through another cell cycle, and so on for generation after generation.

- The most basic function of the cell cycle is to duplicate DNA in the chromosomes and then to segregate the DNA into genetically identical daughter cells → each cell receives a complete copy of the entire genome
- The duration of the cell cycle varies greatly from one cell type to another.

TABLE 18–1 SOME EUKARYOTIC CELL-CYCLE TIMES

Cell Type	Cell-Cycle Times
Early frog embryo cells	30 minutes
Yeast cells	1.5 hours
Mammalian intestinal epithelial cells	~12 hours
Mammalian fibroblasts in culture	~20 hours

The Eucaryotic Cell-Cycle

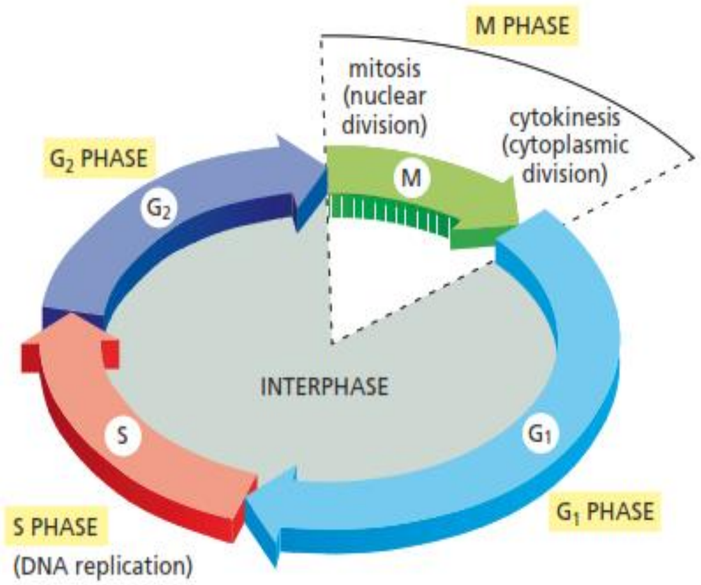


Figure 18–2 The eukaryotic cell cycle usually occurs in four phases. The cell grows continuously in interphase, which consists of three phases: G_1, S, and G_2. DNA replication is confined to S phase. G_1 is the gap between M phase and S phase, and G_2 is the gap between S phase and M phase. During M phase, the nucleus divides in a process called mitosis; then the cytoplasm divides, in a process called cytokinesis. In this figure—and in subsequent figures in the chapter—the lengths of the various phases are not drawn to scale: M phase, for example, is typically much shorter and G_1 much longer than shown.

- The two most dramatic events in the cell cycle are when the nucleus divides, a process called mitosis, and when the cell later splits in two, a process called cytokinesis.
- These two processes together constitute the M phase of the cycle.
- The period between one M phase and the next is called interphase (G1 phase, S phase and g2 phase)
- During all of interphase, a cell generally continues to transcribe genes, synthesize proteins, and grow in mass.
- During these gap phases, the cell monitors both its internal state and external environment.

Cell-Cycle Control System

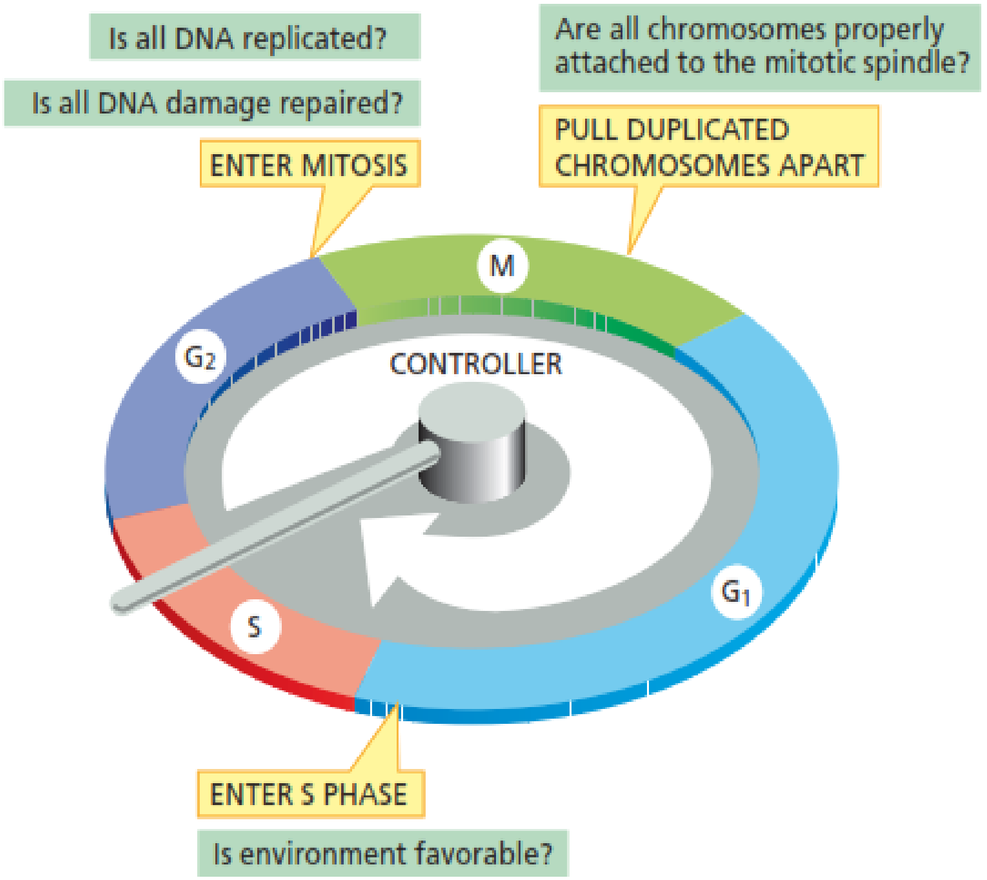
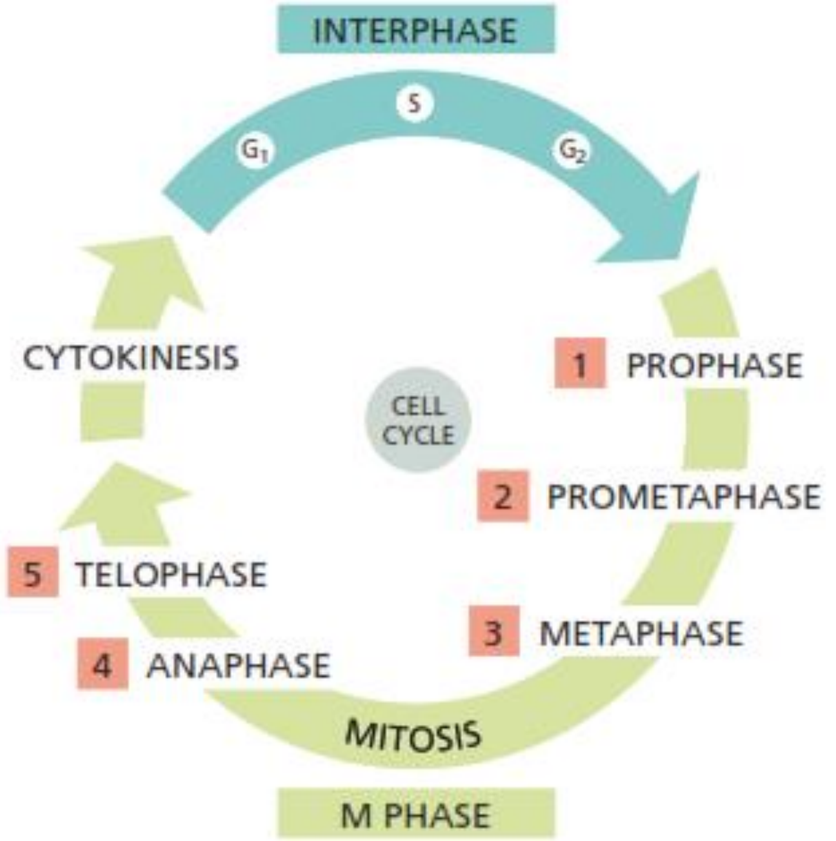


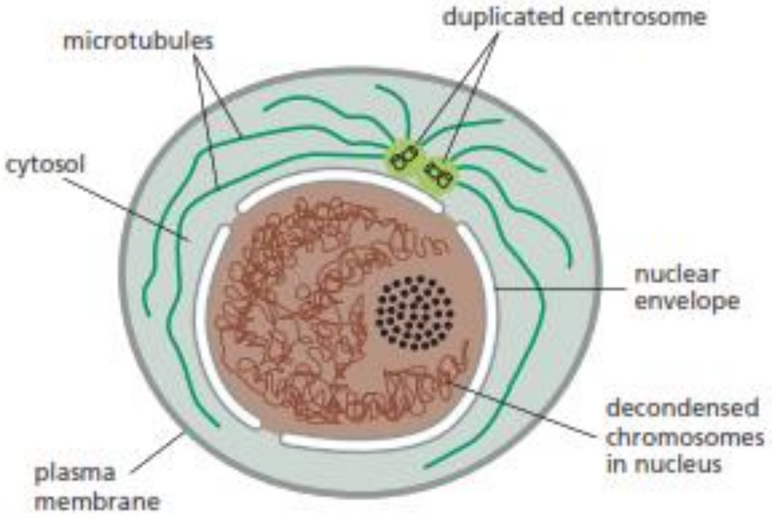
Figure 18–3 The cell-cycle control system ensures that key processes in the cycle occur in the proper sequence. The cell-cycle control system is shown as a controller arm that rotates clockwise, triggering essential processes when it reaches particular transition points on the outer dial. These processes include DNA replication in S phase and the segregation of duplicated chromosomes in mitosis. The control system can transiently halt the cycle at specific transition points—in G_1, G_2, and M phase—if extracellular or intracellular conditions are unfavorable.

CELL DIVISION AND THE CELL CYCLE



The division of a cell into two daughters occurs in the M phase of the cell cycle. M phase consists of nuclear division, or mitosis, and cytoplasmic division, or cytokinesis. In this figure, M phase has been greatly expanded for clarity. Mitosis is itself divided into five stages, and these, together with cytokinesis, are described in this panel.

INTERPHASE



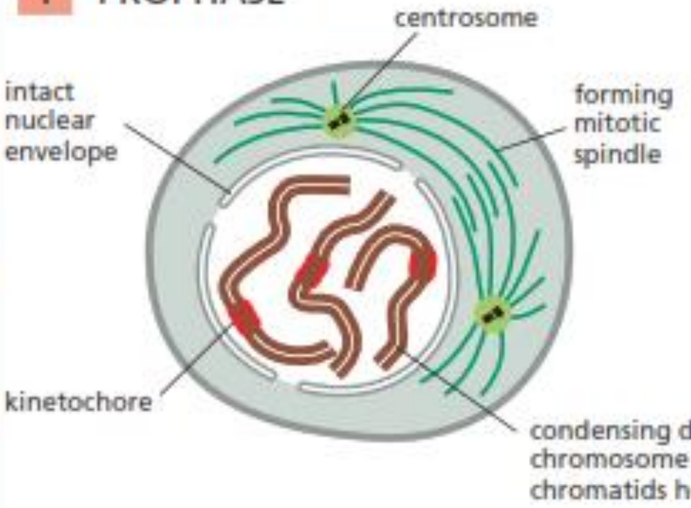
During interphase, the cell increases in size. The DNA of the chromosomes is replicated, and the centrosome is duplicated.

In the light micrographs of dividing animal cells shown in this panel, chromosomes are stained *orange* and microtubules are *green*.

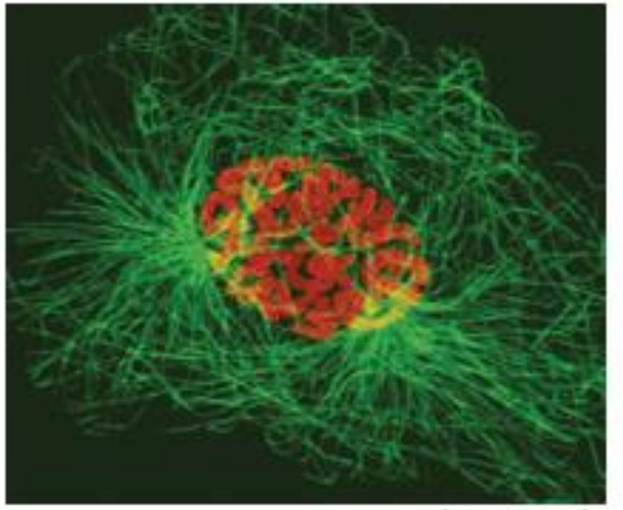
(Micrographs courtesy of Julie Canman and Ted Salmon; "Metaphase" from cover of *J. Cell. Sci.* 115(9), 2002. With permission from The Company of Biologists Ltd; "Telophase" from J.C. Canman et al., *Nature* 424:1074–1078, 2003. With permission from Macmillan Publishers Ltd.)

MITOSIS

1 PROPHASE



At prophase, the duplicated chromosomes, each consisting of two closely associated sister chromatids, condense. Outside the nucleus, the mitotic spindle assembles between the two centrosomes, which have begun to move apart. For simplicity, only three chromosomes are drawn.



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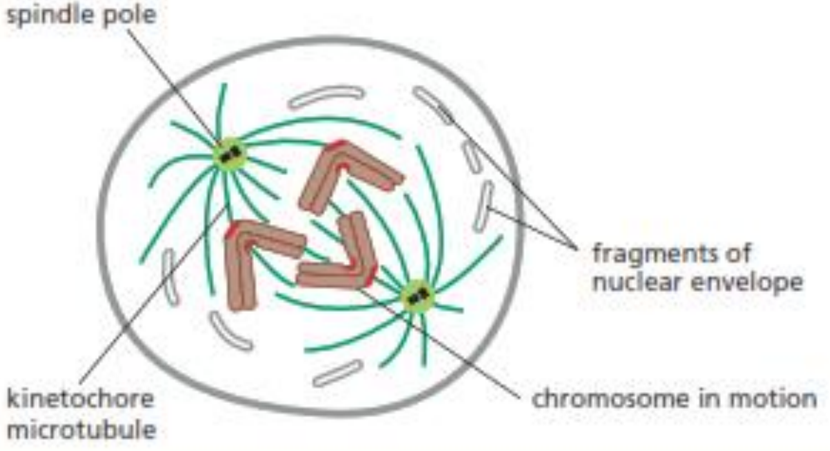
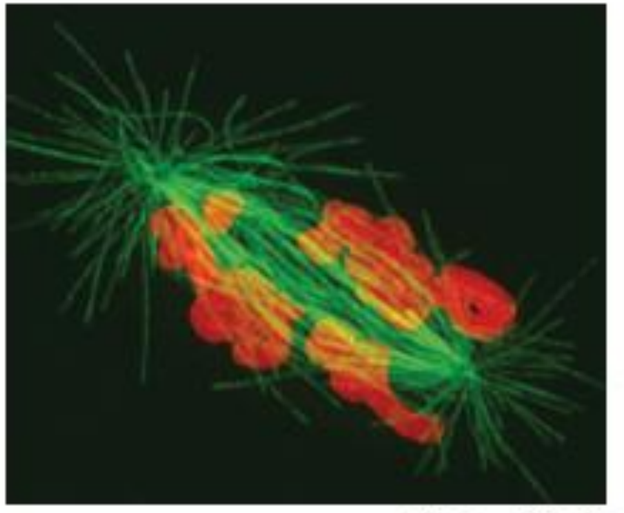
MITOSIS

2 PROMETAPHASE



Prometaphase starts abruptly with the breakdown of the nuclear envelope. Chromosomes can now attach to spindle microtubules via their kinetochores and undergo active movement.



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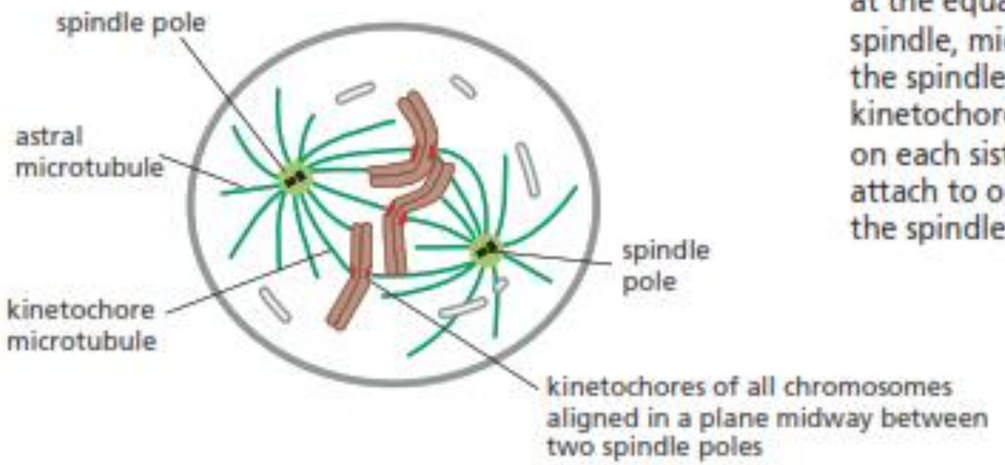
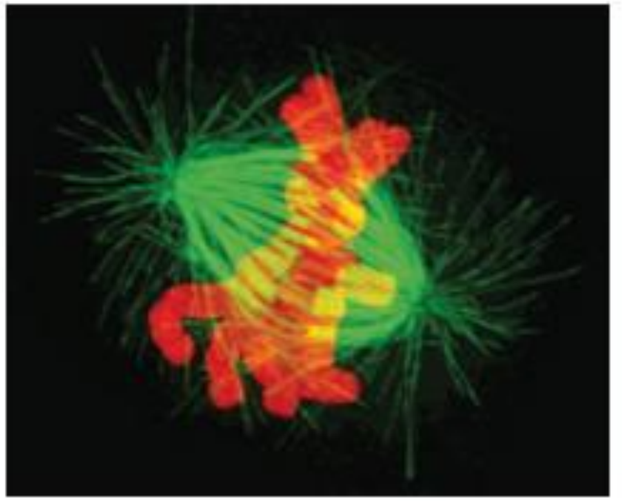
MITOSIS

3 METAPHASE



At metaphase, the chromosomes are aligned at the equator of the spindle, midway between the spindle poles. The kinetochore microtubules on each sister chromatid attach to opposite poles of the spindle.



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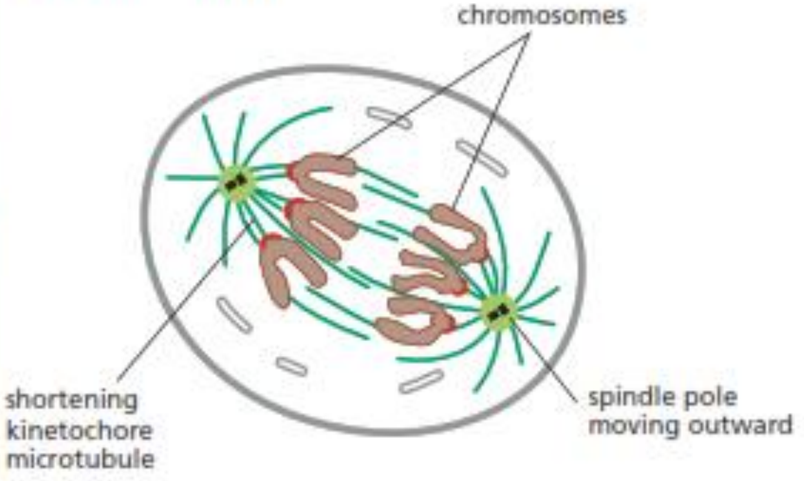
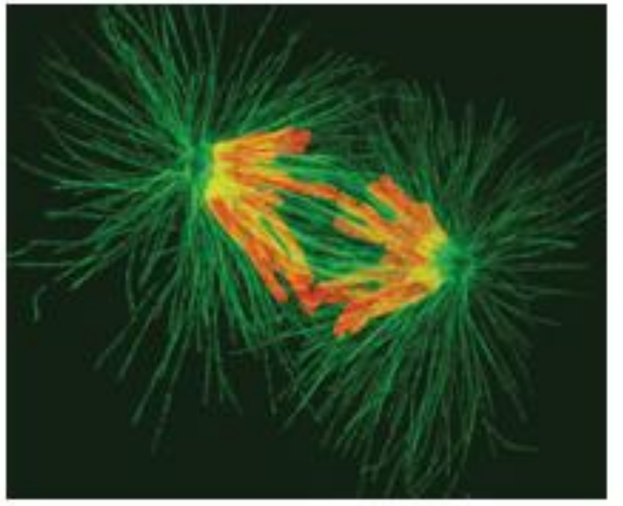
MITOSIS

4 ANAPHASE



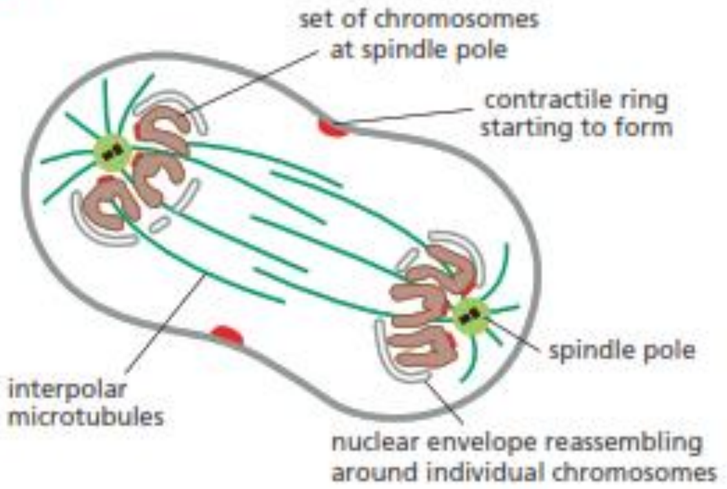
At anaphase, the sister chromatids synchronously separate and are pulled slowly toward the spindle pole to which they are attached. The kinetochore microtubules get shorter, and the spindle poles also move apart, both contributing to chromosome segregation.



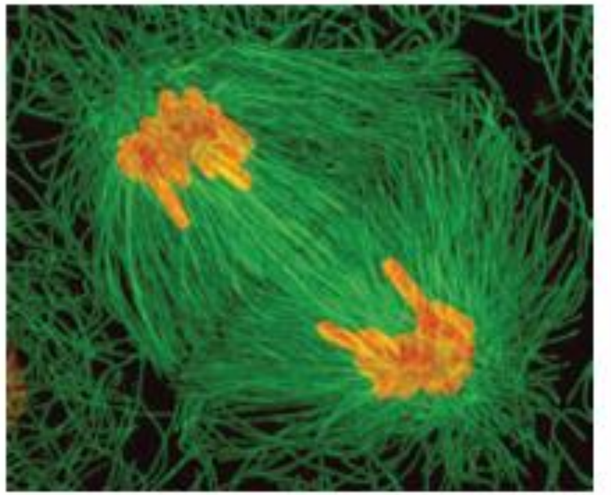
time = 279 min

MITOSIS

5 TELOPHASE



During telophase, the two sets of chromosomes arrive at the poles of the spindle. A new nuclear envelope reassembles around each set, completing the formation of two nuclei and marking the end of mitosis. The division of the cytoplasm begins with the assembly of the contractile ring.



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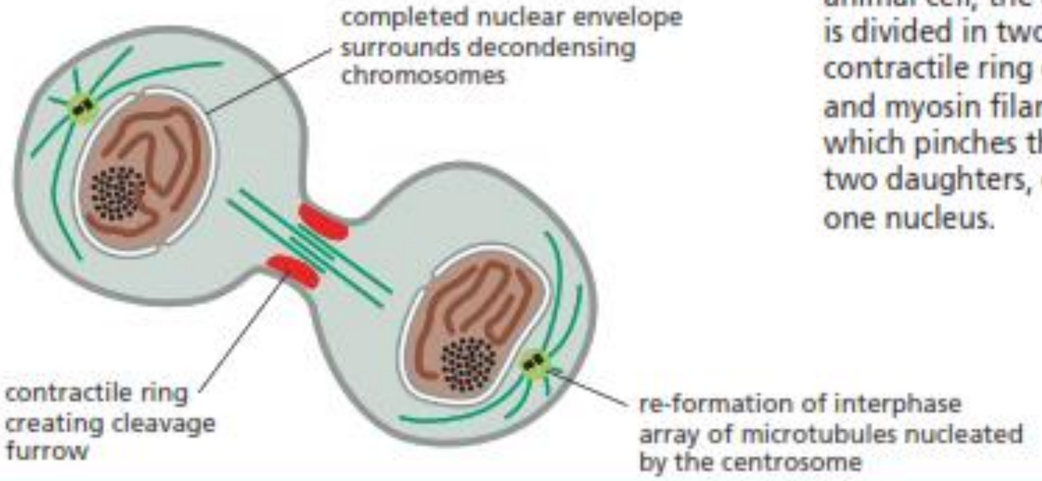
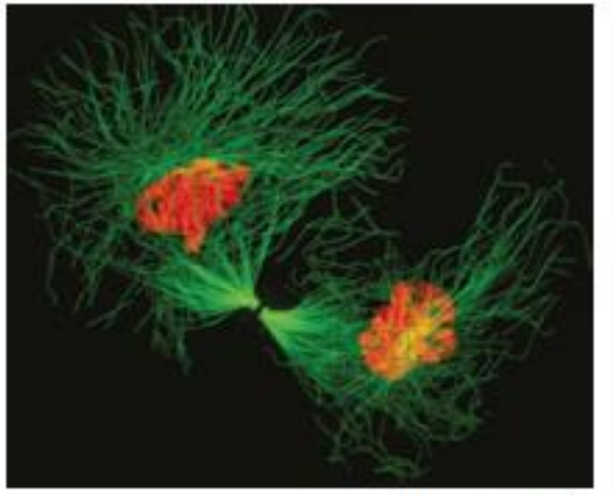
CYTOKINESIS

CYTOKINESIS



During cytokinesis of an animal cell, the cytoplasm is divided in two by a contractile ring of actin and myosin filaments, which pinches the cell into two daughters, each with one nucleus.



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