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What are the Stages of Mitosis

March 10, 2017 • by Lakna • 7 min read

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Cell division is the process where a parent cell divides into two or more daughter cells. In **eukaryotes**, cell division can be classified into two distinct types known as mitosis and meiosis. Mitosis is a vegetative division where each daughter is genetically identical to the parent cell whereas meiosis is a reproductive division where the number of chromosomes in daughter cells are halved to produce **haploid** gametes. The creation of two genetically identical daughter cells is the end result of mitosis. Mitosis has four major stages – prophase, metaphase, anaphase, and telophase, which will be further explained in detail in this article.

This article looks at,

1. What is Mitosis
2. What are the Stages of Mitosis
 - Prophase
 - Metaphase
 - Anaphase
 - Telophase

What is Mitosis

Mitosis is the vegetative cell division in eukaryotes, which divides parent cell's replicated genome between two daughter cells. The two cells are genetically identical, bearing an approximately equal number of organelles and cytoplasm. The mitotic phase is called the M phase of the cell cycle. Eukaryotes have a large number of chromosomes. These chromosomes are replicated during S phase of the interphase of the cell cycle, prior to the entering of the M phase. Replicated chromosomes contain two **sister chromatids** joined together at their centromeres.

Two types of mitosis can be identified among organisms: open mitosis and closed mitosis. During **open mitosis** in animals, nuclear envelope is broken down in order to separate the chromosomes. But in fungi, chromosomes separated in the intact nucleus, which is called **closed mitosis**.

What are the Stages of Mitosis

Mitotic division takes place in four major stages: prophase, metaphase, anaphase, and telophase. The mitotic division is preceded by interphase, which is the phase where the cell copies its DNA in preparation for mitosis. Replicated chromosomes are tightly coiled by chromosome condensation at the interphase. Their centromeres are also attached to kinetochores, an important type of proteins in nuclear division. Proteins required for the cell division are synthesized during the interphase, as well as the cellular components including organelles increase their number. A schematic diagram illustrating mitosis is shown in *figure 1*.

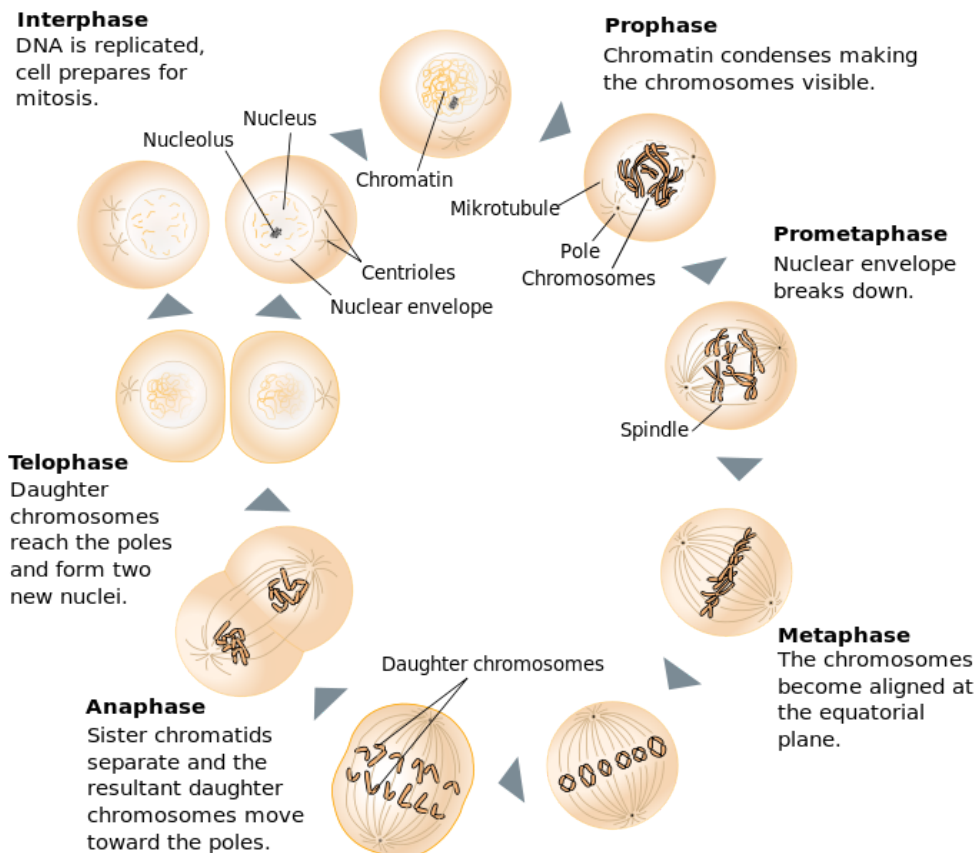


Figure 1: Mitosis at the Cell Cycle

Stage 1: Prophase

Pre-prophase

Pre-prophase takes place only in plants, prior to the prophase. During pre-prophase, the nucleus of the highly vacuolated plants migrates to the center of the cell. The cytoplasm is divided into two along the cell division plane by a transverse sheet called phragmosome. The pre-prophase band, which is a ring of actin filaments along with microtubules is formed during pre-prophase, marking the future position of the mitotic spindle apparatus. Plants do not possess a centrosome, which is the coordinating center of microtubules. Thus, the spindle is formed on the surface of the nucleus, independently assembling the spindle apparatus. The formation of the spindle apparatus breaks down the nuclear envelope.

Prophase

Prophase is considered as the first stage of the nuclear division in mitosis. At early prophase, nucleolus disappears. The chromosomes are tightly coiled and the formation of the mitotic spindle is initiated. Under the high power of light microscope, chromosomes, which contain two sister chromatids and are joined together at the centromere, can be visualized as thin, long, thread-like structures. The coordinating center of the microtubules is the centrosome. Centrosome consists of two centrioles. A pair of centrosomes appear close to the nucleus, which is surrounded by protein fibers, later the microtubule spindle apparatus.

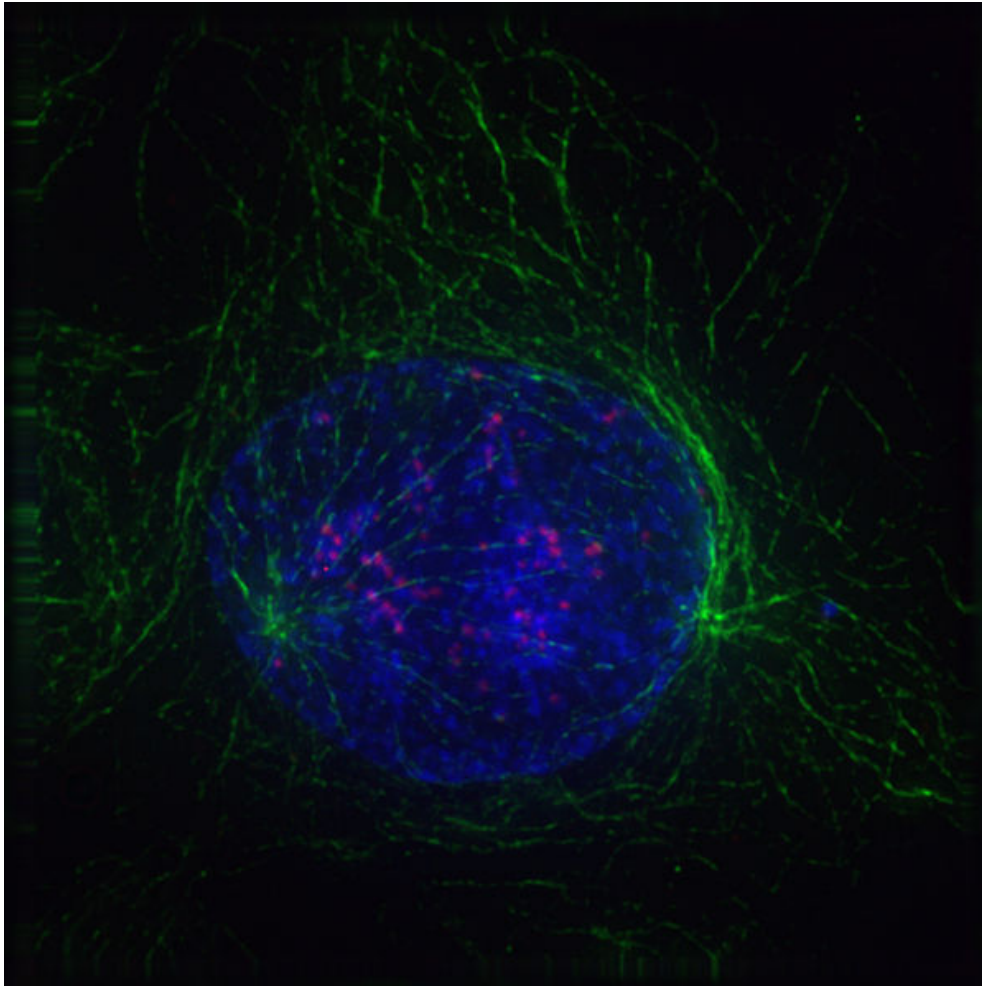


Figure 2: Early Prophase

An early prophase cell stained with fluorescent dyes is shown in *figure 2*. The green strands are the non-kinetochore microtubules, established around the nucleus which is disassembling at the point. The condensing chromosomes are shown in blue color. Centromeres are stained in red color.

Stage 2: Metaphase

Prometaphase

Nuclear envelope disappears by the phosphorylation of the nuclear lamins during the prometaphase of open mitosis. The phosphorylated nuclear lamins cause the disintegration of the nuclear envelope into small membrane vesicles. The disintegration of the nuclear envelope allows the microtubules to invade the nucleus. The kinetochore microtubules are attached to the kinetochores in chromosomal centromeres in the late prometaphase. The growth of the mitotic spindle takes place with the interaction of polar microtubules. A stained early prometaphase cell is shown

in figure 3. Microtubules are invading the disintegrating nucleus, searching for kinetochores and assembling with the centromeres.

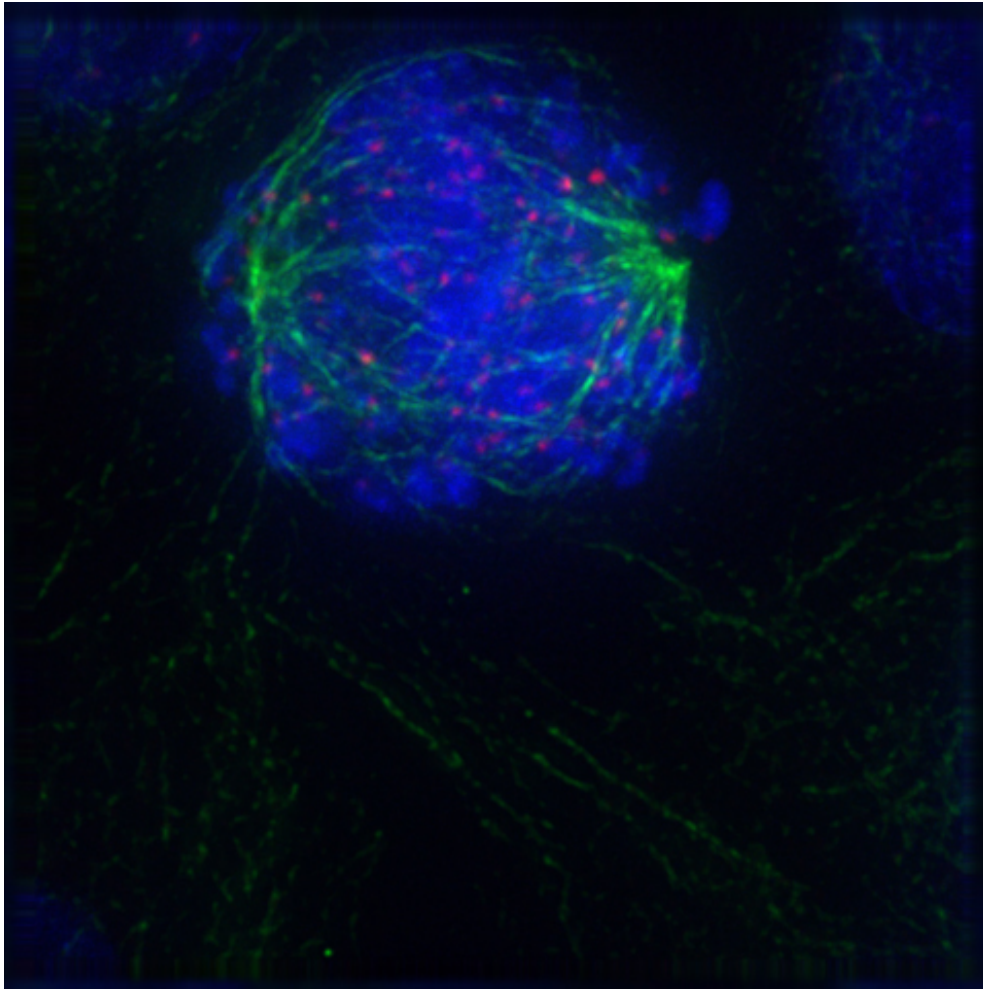


Figure 3: Early Prometaphase

Metaphase

After the location of kinetochores at the centomere, the two centrosomes pull chromosomes towards the opposite poles by contracting the microtubules. Due to the tension, chromosomes are aligned in the equatorial plate of the cell at the metaphase. Metaphase checkpoint ensures the equal distribution of chromosomes at the equatorial plate. The cell is required to pass the metaphase checkpoint in order to proceed to the anaphase. A stained metaphase cell is shown in *figure 4*. The two centrosomes are at the opposite poles of the cell, establishing the spindle apparatus.

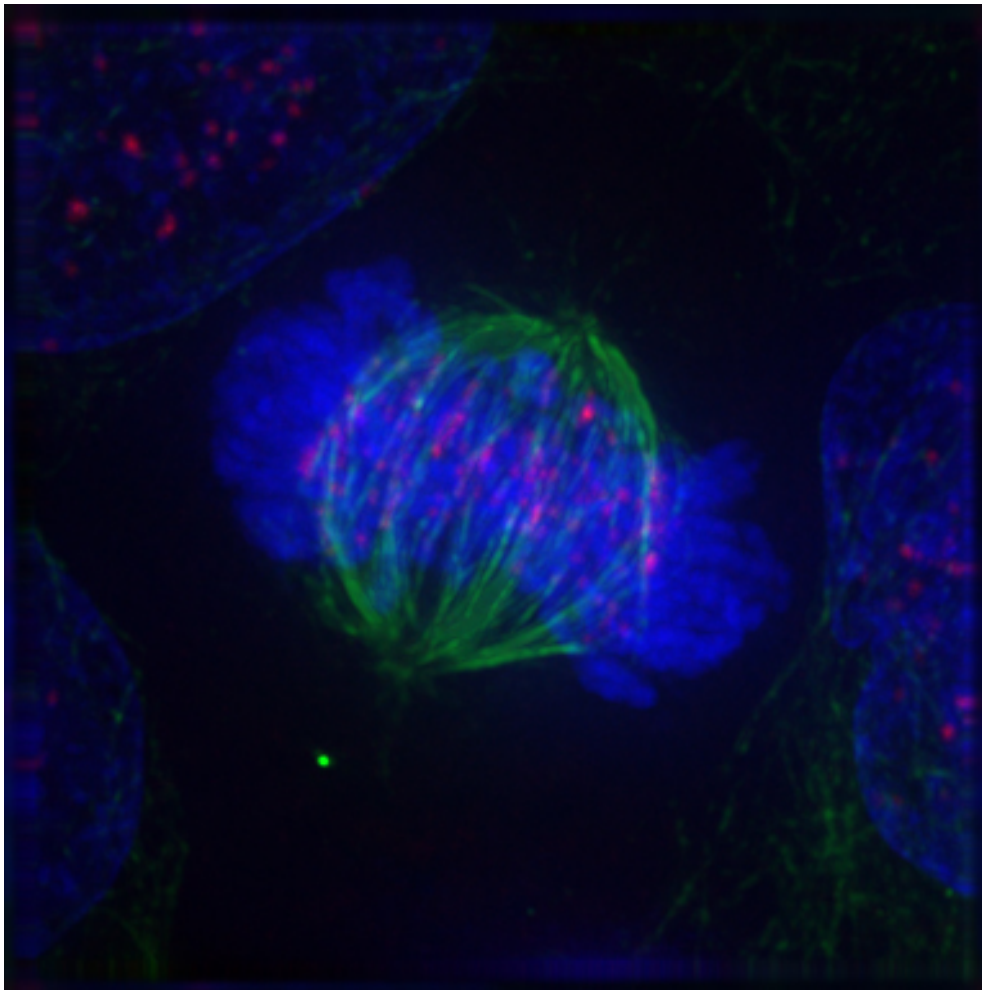


Figure 4: A Stained Metaphase Cell

Difference Between Metaphase 1 and 2

Stage 3: Anaphase

During the *anaphase A*, sister chromatids are separated by the pulling tension generated by the centrosomes, forming two daughter chromosomes. These daughter chromosomes are pulled to the opposite poles by further contracting microtubules. During *anaphase B*, polar microtubules push each other, elongating the cell. Chromosomes are in their maximum condensed level at the late anaphase. They are segregated to reform the nucleus. A stained anaphase cell is shown in *figure 5*. Two chromosome sets are pulled apart by kinetochore microtubules, pushing the cell further apart.

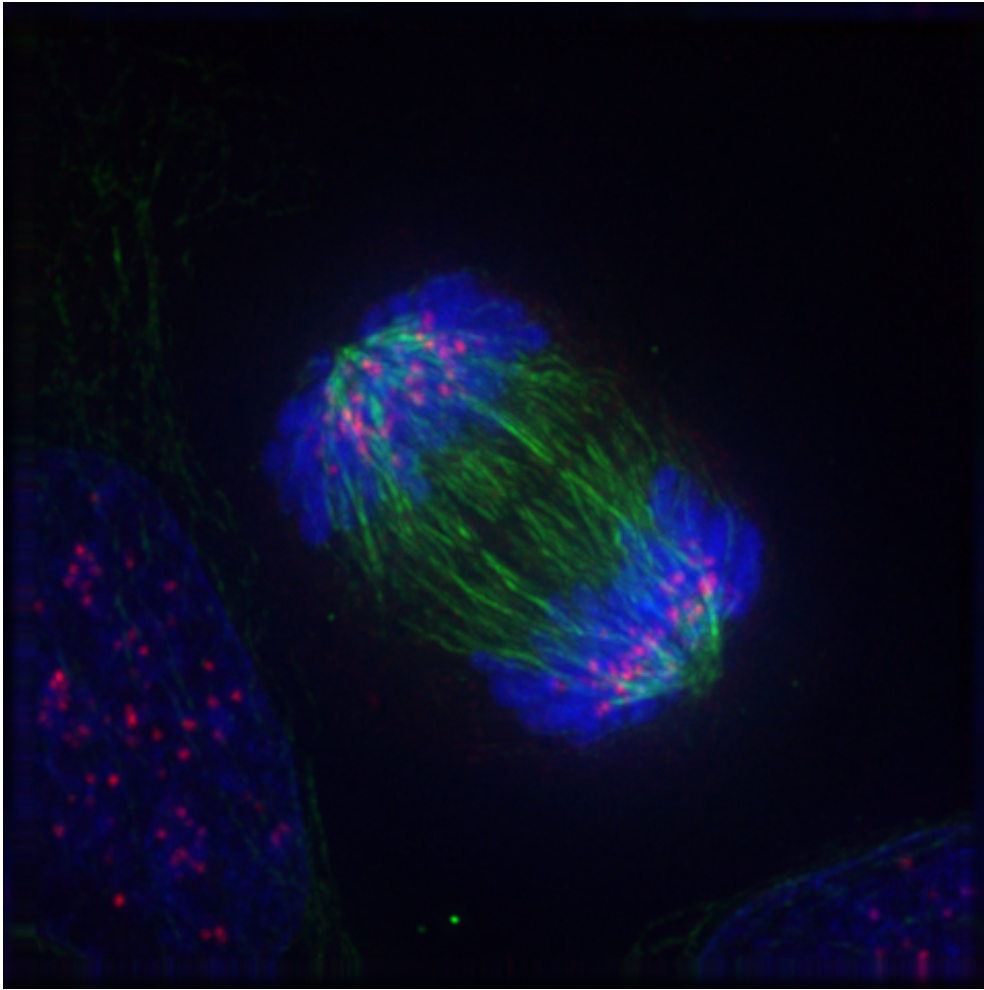


Figure 5: A Stained Anaphase Cell

Stage 4: Telophase

The contracted microtubules are loosened, further lengthening the cell. Two chromosome sets are at the opposite poles. New nuclear envelopes are formed, enclosing each chromosome set by the parent cell's membrane vesicles which disintegrated early. Thus, genetically identical two new nuclei appear. The chromosomes inside each nucleus are decondensed in order to complete mitosis. A stained telophase cell is shown in *figure 6*. The loosening of microtubules lengthen the cell.

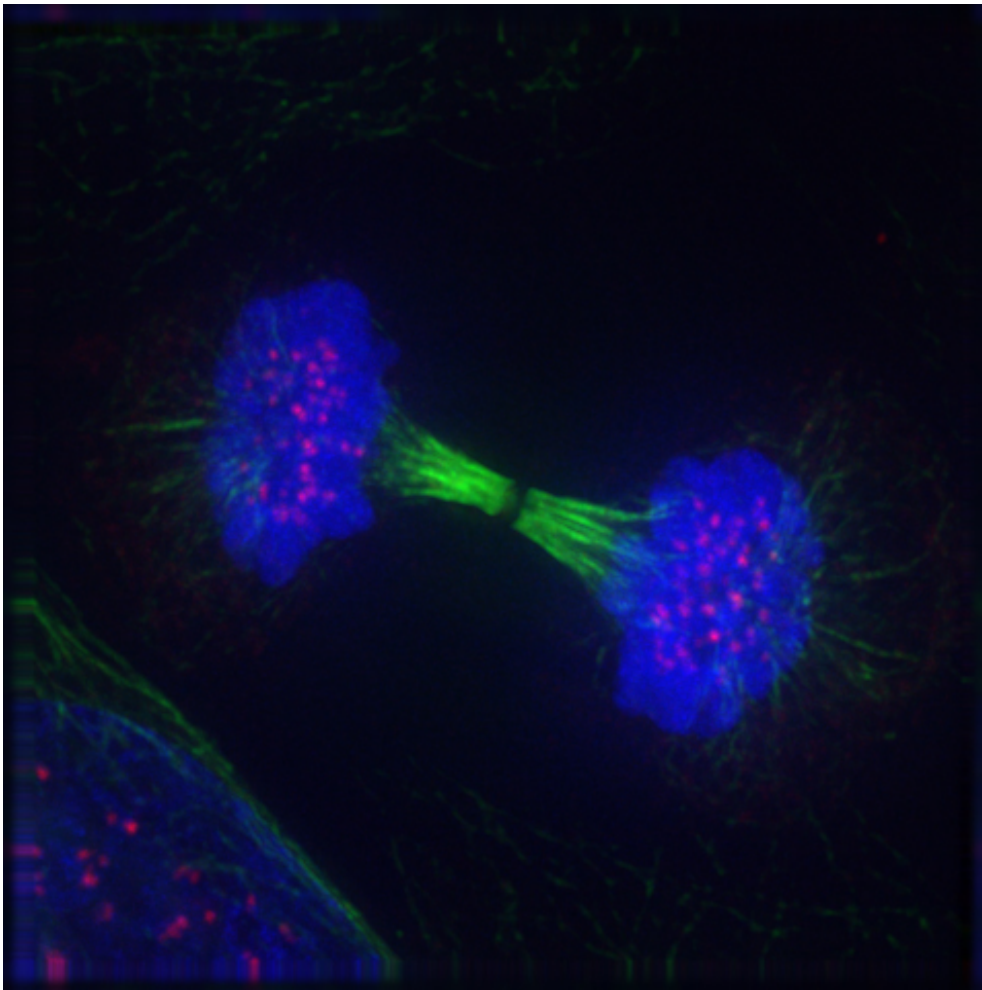


Figure 6: Telophase

Summary

Mitosis takes place during the asexual reproduction of eukaryotes, which produces genetically identical two daughter cells. The DNA in the genome is replicated during the interphase which takes place prior to the entering of the mitotic phase. Replicated DNA contains two sister chromatids in their condensed form of chromosomes. Organelles in the cytoplasm also increase their number during the interphase. Cell's interphase is followed by its mitotic phase, increasing the number of cells.

Mitotic division is mainly composed of four phases: prophase, metaphase, anaphase and telophase. Chromatids are condensed into chromosomes during the prophase. These chromatids are aligned in the equatorial plate of the cell by the forming spindle apparatus. The kinetochore microtubules, which are connected to the centromeres of the chromosomes are contracted, generating a tension on the centromere which holds the two sister chromatids together at the anaphase. This tension leads to the cleavage of cohesion protein complexes in the centromere, separating the two sister chromatids apart and producing two daughter chromosomes. These daughter chromosomes are pulled towards the opposite poles by further contraction of the kinetochore microtubules during telophase which is the final phase of the mitotic division. After completing the M phase, parent cell undergoes cytoplasmic division which is known as cytokinesis, resulting in genetically identical two separated cells.

Reference:

1. "Mitosis". En.wikipedia.org. N.p., 2017. Web. 9 Mar. 2017.

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Lakna, a graduate in Molecular Biology & Biochemistry, is a Molecular Biologist and has a broad and keen interest in the discovery of nature related things

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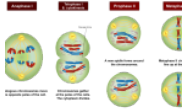
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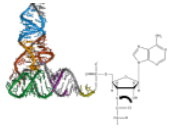
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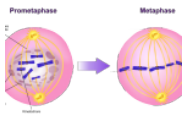
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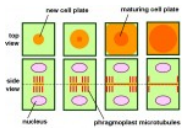
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