

The Eukaryotic Cell Cycle

Slide 2 The eukaryotic cell cycle is somewhat more complex than the prokaryotic growth cycle. In large part this is because eukaryotic cells contain multiple chromosomes within a membrane-bound nucleus, rather than a single circular chromosome within the cytoplasm. Because of this, the processes of DNA replication and partitioning are somewhat more complex.

During cell division, eukaryotic chromosomes follow a very prescribed series of events, almost like a choreographed dance, as they replicate and move from one parent cell into two daughter cells.

Many eukaryotic cells do not continuously divide. Instead many eukaryotic cell types mature, or differentiate, and perform specific functions in an organism.

The eukaryotic cell cycle consists of two basic stages: interphase and mitosis.

Cells spend the majority of their time in interphase, which consists of three stages called Gap 1 (G1), Synthesis (or S), and Gap 2 (G2).

The remainder of the cell cycle is called the mitosis phase (M) and consists of mitosis and cytokinesis, where two genetically identical daughter cells are formed.

Slide 3 In the G1 phase, the cell is growing and replicating cytoplasmic organelles. It is also preparing for replication of its DNA by synthesizing the enzymes necessary to make copies of its DNA.

Most eukaryotic cells, except those of plants, contain centrioles. During G1, centrioles replicate and the copies begin to move to opposite ends of the cell. The paired centrioles are surrounded by a centrosome. The centrosome is analogous to a region in plant cells called the microtubule organizing center.

DNA is synthesized during S phase so that two exact copies of the chromosomes are produced.

During the G2 phase cells are preparing for division. This involves the supercoiling and winding of DNA to 'package' it into chromosomes, and the synthesis of enzymes and structural components required for cell division. The centriole-centrosome complexes that replicated during G1 now begin to orchestrate the formation of a mitotic spindle that will control the movement of the cell's chromosomes as one cell divides into two daughter cells.

Slide 4 Mitosis occurs during the M phase of the eukaryotic cell cycle. During this phase, the cell divides and partitions copies of its chromosomes, and about half of its

organelles and cytoplasm, into each of two daughter cells. Mitosis is divided into four stages: prophase, metaphase, anaphase, and telophase.

After mitosis is complete, the cytoplasmic contents, including the chromosomes, are divided and distributed into the two daughter cells that result from the process of cell division, or cytokinesis.

Slide 5 During prophase DNA is packaged into very tightly wound chromosomes that consist of both DNA and protein. At this time, each chromosome consists of two identical arms, called sister chromatids. These chromatids were formed during the replication of DNA in S phase and are held together at a more or less centrally located constriction, called a centromere.

As we will soon see, each chromosome will supply one chromatid to each daughter cell. In this way, each daughter cell receives one exact copy of the entire genome of the original parent cell.

Slide 6 Several other events also take place during prophase. First, the nuclear envelope is broken down into vesicles. This is followed by the completion of a mitotic spindle that consists of microtubules. The microtubules originate from the centrosomes that are positioned at opposite ends of the cell, and attach to specialized structures on the chromosomes, called kinetochores.

Slide 7 The last three phases of mitosis are fairly simple. During these phases the chromosomes are lined up and the sister chromatids are pulled to opposite poles of the cell.

During metaphase the chromosomes of the cell line up along the plane of cell division, which is called the equatorial plate. The equatorial plate marks where the cell will divide, and plays an important role in the correct distribution of chromosomes and other cell material during the subsequent stages of cell division.

At this point, each chromosome has at least two microtubules attached to it – one from each pole of the cell.

During anaphase, the two sister chromatids of each chromosome separate and move to opposite poles of the cell. Keep in mind that this means that one exact and complete copy of the cell's DNA is going to each end of the cell. The sister chromatids that have separated will now become the daughter chromosomes of the two cells that will form once the cell divides. Movement of the chromatids is accomplished by the shortening of the microtubules, and by the movement of the chromatids along the microtubules.

In the last phase, the chromatids reach opposite poles of the cell, the nuclear envelopes reform around each set of chromatids, and the chromatids themselves become less condensed. This last phase of mitosis is called telophase.

Slide 8 Cytokinesis follows mitosis, and it is the last stage of the cell cycle. While mitosis accomplished the division of one nucleus into two nuclei, cytokinesis divides the entire cell into two new cells.

The details of cytokinesis vary among different kinds of organisms. For example, animal cells, divide by a constriction of their cell membrane. This constriction is called a cleavage furrow, and it forms in the same plane as the metaphase equatorial plate. In contrast organisms such as plants and fungi have cell walls and undergo cytokinesis a bit differently. In these organisms, vesicles from the Golgi apparatus migrate to the plane of cell division and fuse to form a cell plate. This plate will become the new cell membranes and cell walls that separate the two daughter cells.

Slide 9 At this point, the cell cycle has been completed.

The cell prepared for DNA replication during G1 and replicated its DNA during S phase. Preparations for cell division occurred during G2, and the cell divided during M phase. The end result of this cycle is that one parent cell divided to produce two new daughter cells, which are genetically identical to each other and to the original cell.

From here, the cell has two possible fates. If the cell is located in an area of actively growing and dividing cells, such as the epidermis of humans or an apical meristem of plants, it can continue through more rounds of the cell cycle and continue to divide. On the other hand, in tissues or areas where cells are not actively dividing, the cell cycle will stop in G1 where it may remain for days, months, years, or for the entire life of the cell.

In the following lesson, we will briefly discuss some of the cues that dictate whether or not a cell proceeds through the cell cycle and divides again, or is halted in G1.