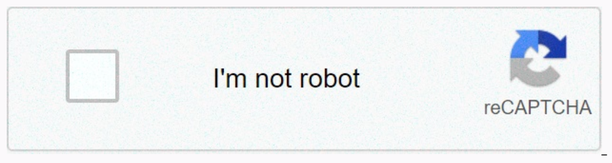

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Eukaryotic cell cycle worksheet

Eukyotes have two main types of cell division: mitosis and meiosis. Mitosis is used to grow and cure new cells, while meiosis is used to produce venic cells (eggs and sperm). Meiosis will be discussed in a later chapter. The cell cycle is an orderly sequence of events that involves cell growth and cell division, which produces two new daughter cells through mitosis. The length of the cell cycle varies widely even in the cells of individual organisms. In humans, the frequency of cell turnover ranges from a few hours to early embryonic development with an average of two to five days of epithelial cells, or an entire human life spent without having to divide into specialized cells such as cortical neurons or heart muscle cells. There is also a deviation in the time that a cell spends at each stage of the cell cycle. When rapidly dividing mammalian cells are cultured (outside the body under optimal growing conditions), the cycle length is approximately 24 hours. The timing of cell cycle events is governed by mechanisms that are both inside and outside the cell. Cells on the road to cell division are moving through a series of precisely timed and carefully regulated stages of growth, DNA replication, and division to produce two genetically identical cells. The cell cycle has two main phases: the interphasic and the mitotic phase (Figure 1). During the interphases, the cell grows and the DNA replicates. In the mitotic phase, the reproduced DNA and cytoplasmic content are separated and the cell divides. Figure 1: The cell passes through a sequence of phases in an orderly manner. During interphases, G1 includes cell growth and protein synthesis, Phase S involves DNA replication and centrosome replication, and G2 involves further growth and protein synthesis. The mitotic phase follows interstasis. Mitosis is a nuclear division in which duplicate chromosomes are separated and divided into female nuclei. Usually, the cell is divided after mitosis in a process called cytokinesis, in which it is divided in the cytoplasm and two daughter cells form. Interphases During interphases, the cell goes through normal processes, while also preparing for cell division. For a cell to move from the interphasic to the mitotic phase, a number of internal and external conditions must be met. The three stages of the interphases are called G1, S and G2. The first stage of interphases is called phase G1 (first gap) because there are few changes from a microscopic point of view. However, in the G1 stage, the cell is quite active at the biochemical level. The cell accumulates the building blocks of chromosome DNA and related proteins and accumulates sufficient energy reserves to replicate each chromosome. During interphases, nuclear DNA remains in a semi-condensed chromatin. In phase S, DNA replication can proceed through mechanisms that result in the formation of identical pairs of identical DNA molecules — sister chromids — that are firmly linked to the centromeric region (Figure 2). Figure 2 DNA replication during phase S copies each linear chromosome. Chromosomes remain connected in a region called centromere. Photo credit: Lisa Bartee's Centrosome is duplicated during phase S. The two centrosome gives rise to the mitotic spindle of the device, which orchestrats the movement of chromosomes during mitosis. In the center of each animal cell, animal cells centrosomes are attached to rod-like objects, centriole that are at right angles to each other. Centrioles help organize cell division. Centrioles are not present in centrosomes of other eukariotic species, such as plants and most fungi. Figure 3 (a) Structure of the centriole forming the centrosome. (b) Centriole results in the mitotic spindle (grey fibre-like structures). Photo credit: CNX OpenStax Microbiology. During the G2 phase, the cell replenishes its energy stores and synthesizes the proteins needed for chromosome manipulation. Some cell organelles are duplicated, and cytoskeleton break down to provide resources for the mitotic phase. There may be further cell growth during G2. Final preparations for the mitotic phase must be completed before the cell can enter the first stage of mitosis. The mitotic phase figure 4: Mitosis of onion root cells. The cells in the picture are at different stages of mitosis. (Credit: Spike Walker. Wellcome Images images@wellcome.ac.uk) To make two daughter cells, the contents of the nuclei and cytoplasm must be divided. The mitotic phase is a multi-stage process in which duplicate chromosomes are aligned, separated and placed in opposite poles of the cell, and then the cell is divided into two new identical daughter cells. The first part of the mitoche phase, mitosis, consists of five stages that implement the nuclear department (Figure 5). The second part of the mitotic phase, called cytokinesis, is the physical separation of the cytoplasmic components of two daughter cells. Although the stages of mitosis are similar to those of most eukyotes, the process of cytokizis is quite different from eukyotes, which are cell walls, such as plant cells. Figure 5 Summary of the process of mitosis. Photo credit Oganesson007, Wikimedia. Prophase The profase of the first phase of the nuclear envelope begins to fragment into small vesicles, and the membrane organelles (such as the Golgi apparatus and endoplasmic reticulum), fragment and disperse towards the edges of the cell. The nucleolus disappears. Centrosomes begin to move into opposite poles of the cell. The microtubules that make up the mitotic orsa push them farther apart than the microtubule fibers lengthen. Sibling chromatids coil more tightly with the help of condensin proteins and become visible under a light microscope. Figure 6 Prophase. Photo credit Kelvin13; Wikimedia. Prometaphase The first phase of change during prometaphasia, the process started in many profasia, continues to develop. Remains of the nuclear envelope fragment. The mitotic spindle continues to evolve as more microtubules gather and stretch over the length of the former nuclear site. Chromosomes condense and become more discreet. All sibling chromatid develops a protein structure called kinetochore in the centromeric region. Figure 7 Prometaphase. Photo credit Kelvin13; Wikimedia. The proteins in the kinetochore attract and bind to mitotic spindle microtubules. Just as spindle microtubules come from centrosomes, some of these microtubules come into contact with and bind firmly to kinetochores. After a mitotic fiber attaches to the chromosome, the chromosome becomes oriented until the kinetochores of the sibling chromatids face the opposite poles. Finally, all sibling chromatids will be attached via kinetochores to the microtubules of opposite poles. Spindle microtubules that are not related to chromosomes are called polar microtubules. These microtubules overlap halfway between the two poles and contribute to the elongation of cells. Astral microtubules are located near the poles, they help them in spindle orientation and are necessary to control mitosis. Figure 8 During prometastasis, mitotic spindle microtubules from opposite poles are attached to all sibling aromas at every kintochore. Anaphase, the relationship between the sibling chromatids breaks down and the microtubules pull the chromosomes toward opposite poles. Metaphase During the metaphase, the change phase, all chromosomes, is aligned in a plane called a metaphase plate or equatorial plane, halfway between the two poles of the cell. The sibling chromatids are still closely related to cohesin proteins. At this time, chromosomes are condensed to the maximum. Figure 9 Metaphase. Photo credit Kelvin13; Wikimedia. Anaphase Anaphase, the upward phase, the cohesin proteins degrade, and the sibling chromatids separate from the centrome. All chromatids, now called chromosomes, are pulled quickly toward the centrosome to which the microtubule is attached. The cell visibly elongates (oval shape) as polar microtubules slide against each other at the metaphasic plate, where they overlap. Figure 10 Anaphase. Photo credit Kelvin13; Wikimedia. Telophase During telophase, the distance phase, the chromosomes reach the opposite poles and begin to decondense (unravel), relaxing in a chromatin configuration. Mitotic spinders are depolymerized into tubulin monomers, which for each daughter cell, it is used for the assembly of cytoskeletal components. Nuclear envelopes form around chromosomes, and nucleosomes appear within the nuclear area. Figure 11 Telophase. Photo credit Kelvin13; Wikimedia. Cytokinesis Cytokinesis, or cell movement, is the second large phase of the mitotic phase, during which cell division is completed through the physical separation of the cytoplasmic components of two daughter cells. The division is not completed until the cell components have been divided and completely distributed to the two daughter cells. Although the stages of mitosis are similar to those of most eukyotes, the process of cytokizis is quite different from eukyotes, which are cell walls, such as plant cells. In cells, such as animal cells, which are not cell walls, cytokinesis follows the formation of anaphase. Contract ring consisting of actin fibres in the plasma membrane of the former metaphases plate (Figure 12). Actin fibers pull the cell's equator inward and form a rift. This crevice, or crack, is called cleavage groove. The groove deepens as the actin ring contracts, and eventually the membrane splits in two. In plant cells, a new cell wall must form between the daughter cells. During the interphase, the Golgi device accumulates enzymes, structural proteins and glucose molecules before breaking into blisters and dispersing on the dividing cell (Figure 12). During telophase, these Golgi vesicles are transported on microtubules to form a fragmoplast (bladder structure) on the metaphase plate. There, the vesices merge and merge from the center to the cell walls; this structure is called a cell plate. As more and more blisters merge, the cell disc expands until it merges with the cell walls on the periphery of the cell. Enzymes use glucose, which is accumulated between membrane layers, to build a new cell wall. Golgi membranes on both sides of the new cell wall become part of the plasma membrane. Figure 12 In the course of cetocinesis of animal cells, the metaphases plate develops a ring of actin fibers. The ring contracts, which forms a cleavage groove that divides the cell in two. In plant cells, Golgi vesicles merge with the former metaphasic plate, forming a phragmoplast. The cell plate formed by the fusion of phragmoplast vesiccles grows from the center to the cell walls, and the membranes of the vesices merge to form a plasma membrane that divides the cell in two. Summary of mitosis and cytokinesis 13. The lower images were taken by fluorescent microscopic examination of cells artificially stained with fluorescent dyes: blue fluorescence designates DNA (chromosomes) and green fluorescence means microtubules (spindles). (credit mitosis drawings: The work of Mariana Ruiz Villareal; credit micrographs: Modification of roy van heesbeen's work; credit Cytokinesis Micrograph: Wadsworth Center/New York State Department of Health; scale-bar data from Matt Russell) G0 Phase Not all cells hold themselves to the classic cell-cycle pattern, in which a newly formed daughter cell immediately enters interphases, closely following the mitotic phase. Cells in the G0 phase are not actively preparing for division. The cell is in the resting (inactive) phase after exiting the cell cycle. Some cells temporarily enter G0 until an external signal triggers the formation of G1. Other cells that never or rarely divide, such as mature heart muscle and nerve cells, remain permanently in the G0). References, unless otherwise indicated, images on this site are allowed in CC-BY 4.0 by OpenStax. OpenStax, Biology. OpenStax CNX. Article 6 s8Hh0oOc@9 Vbi92lHB@9 s8Hh0oOc@9 201 Vbi92lHB@9. May 27, 2008

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