Mitosis Overview

Genetics > The Cell Cycle > The Cell Cycle

Somatic cells
• Most of the body's cells • Diploid (2n) : 46 chromosomes
Reproductive cells: gametes
• Sperm and egg cells • Haploid (1n): 23 chromosomes
INTERPHASE
• Cell doubles in size and DNA during interphase • 90-95% of cell cycle • G1: cell grows without replicating DNA • S: synthesis phase, DNA replicates • G2: cell synthesizes proteins in preparation for mitosis • Chromosomes condensed during mitosis: uncondensed (chromatin form) for rest of cell cycle
MITOSIS

• Somatic cell division

Prophase
• Centrosomes migrate to opposite sides of cell • Mitotic spindles form from centrosomes
Prometaphase
• Nuclear envelope fragments • Nucleolus disappears • Sister chromatids attached to each other at their centromeres until anaphase
Metaphase
• Chromosomes line up at metaphase plate
Anaphase
• Sister chromatids move to opposite sides of cell
Telophase
• Nuclear envelope reforms
Cytokinesis
• Cytoplasm divides cell into two • Produces 2 diploid daughter cells with identical genomes
Mitosis
• Division of nucleus into 2 daughter nuclei
Cytokinesis
• Division of cytoplasm CLINICAL CORRELATION
Aneuploidy
• Sister chromatids do not separate properly during cell division (mostly meiosis but also occurs during mitosis) • Daughter cells with extra or missing chromosome • Common in cancer cells

FULL-LENGTH TEXT

• Here, we will learn mitosis and the eukaryotic cell cycle. We will specifically use human cells as our model.

• To begin, start a table to learn the two types of human cells.

• Denote that they include:

- Somatic cells, which describes most of the body's cells.

- Reproductive cells, which are sperm and egg cells aka gametes.

• These two types of cells contain different amounts of chromosomes.

- Denote that somatic cells contain 46 chromosomes total and that they are diploid because they contain two sets of 23 chromosomes, one set inherited from each parent.

- Denote that reproductive cells contain 23 chromosomes, and that they are therefore haploid.

In this tutorial we describe somatic cell division: mitosis.

To begin, let's learn the duration of phases in the cell cycle.

• First, draw a pie chart; it represents the cell cycle of a dividing human cell, which lasts about 24 hours.

• Denote that the cell cycle divides into two major periods:

- Interphase, in which the cell grows and prepares for cell division.

- Mitosis (M-phase), in which the cell divides.

• Show that 90-95% of the pie chart is interphase, and the remaining is mitosis.

- Mitosis takes up about 1 hour of the 24-hour human cell cycle.

• Illustrate that interphase itself comprises three separate phases:

- G1, in which the cell grows without replicating DNA.

- S, the "synthesis" phase in which DNA replicates.

- G2, during which the cell synthesizes proteins in preparation for mitosis.

• During interphase, the cell doubles in size and amount of DNA.

Now, before we learn the phases of mitosis, let's track a single chromosome through the cell cycle to learn how the amount of genetic material changes before and after cell division.

• Start with interphase.

• Draw an uncondensed chromatin fiber within a cell.

- Each chromatin fiber is a single chromosome.

• Indicate that the chromatin fiber replicates in the S phase.

• Now, show that in mitosis, the original chromosome and its duplicate condense.

• Label each condensed chromosome "sister chromatid."

• Indicate that the sister chromatids connect at the centromere.

• Show that by the end of the mitotic phase, sister chromatids separate, which evenly distributes genetic material between two daughter cells.

• As a clinical correlation, denote that aneuploidy results when sister chromatids do not separate properly during mitosis.

- This results in daughter cells with an extra or missing chromosome (or chromosomal region).

- Aneuploidy is common in somatic cancer cells, in which cell division is rapid and prone to errors.

Now, let's learn the discrete phases of the mitotic period. As a reminder, the original set of 46 chromosomes replicates in the S phase, doubling the genetic material in the cell. Thus, throughout mitosis there are 46 pairs of chromosomes in the cell.

• Illustrate that mitosis comprises 5 different phases:

- Prophase

- Prometaphase

- Metaphase

- Anaphase

- Telophase

• Indicate that cytokinesis, or the splitting of cytoplasm between two daughter cells, concludes the cycle.

- Cytokinesis is often considered part of telophase, and not a discreet phase in itself.

Let's draw each of these phases in sequence.

Start with prophase.

• Draw a cell that encloses an intact nucleus.

• Illustrate duplicated, condensed chromosomes within the nucleus.

- We will only include two of the 46 pairs of chromosomes for simplicity.

• Show a nucleolus within the nucleus.

• Outside of the nucleus, draw two centrosomes, each enclosing a pair of centrioles.

• Draw microtubules emerging from the centrosomes in all directions.

- These microtubules nucleate from the centrosome during interphase, but lengthen during prophase.

• Show that they form a mitotic spindle between the centrosomes.

Now, draw prometaphase.

• Draw a cell with a fragmented nuclear envelope.

- Prometaphase begins as soon as the envelope begins to fragment.

• Indicate that the nucleolus disappears.

• Show the centrosomes (and centrioles) at opposite poles of the cell.

- The centrosomes remain at these poles until cell division.

• Label them "mitotic spindle poles."

• Again, draw microtubules emerging from the centrosomes.

• Indicate that the spindle fibers attach to kinetochores on sister chromatids.

- Each sister chromatid has a kinetochore that faces the opposite pole.

• Importantly, show that the spindle fibers attach the sister chromatids in each chromosomal pair to opposite poles.

• Once attached, the chromosomes move about within the cell.

Next, let's draw metaphase.

• Draw a cell similar to prometaphase, but with chromosomes lined up along the metaphase plate, which is the region approximately midway between each spindle pole.

Now, draw anaphase.

• Draw a slightly elongated cell with a fragmented nucleus.

• Show that the spindle fibers separate the sister chromatids and pull them towards each spindle pole.

• Next, use arrows to show that the spindle poles themselves move farther away from each other and elongate the spindle.

Now, draw telophase, the last phase.

• Draw an elongated cell with a contractile ring in the middle.

- The contractile ring comprises actin and myosin and forms a "cleavage furrow" in the cell.

• Show that the daughter chromosomes arrive at the spindle poles, and that microtubule spindle fibers, those that were not attached to sister chromatids, overlap at the center of the cell.

• Indicate that a nuclear envelope forms around the chromatids as they decondense.

- The formation of these nuclear envelopes marks the end of mitosis.

• Show that the nucleolus reappears in this phase.

Finally, let's draw cytokinesis, in which the cytoplasm divides amongst the two daughter cells.

• Draw a cell with a now deepened cleavage furrow.

• Illustrate that the microtubule spindle disassembles in this phase.

• Show that the nuclear envelopes completely reform.

• Denote that mitosis describes the division of the nucleus into two daughter nuclei.

• Denote that cytokinesis describes the division of cytoplasm.

• Now, show that the contractile ring contracts and pinches the cell into two daughter cells.

- Label them diploid.

Mitosis results in the formation of two daughter cells, each with two sets of 23 chromosomes.

• Many factors regulate the progression of a dividing cell through this cycle, and several checkpoints ensure that both daughter cells receive a complete genome at the end of it.

References:
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