The Cell Cycle — Cell Division

Cells alternate between stages, i.e. phases of dividing and not dividing. This sequence of phases is called the cell cycle. The purpose of the cell cycle is cell division: for processes of growth and repair.

The three stages of the cell cycle are: 1. interphase, 2. mitosis, 3. cytokinesis.

Cells grow and prepare to divide during interphase.
Cell division occurs during mitosis and cytokinesis.

Interphase:

This is the longest phase of the cell cycle.
At this stage the cell is carrying out its life activities, e.g. growing, respiration, etc.
When the cell prepares for cell division, the chromosomes are duplicated, so that there are now two identical strands of chromosomes; i.e. this is the phase of the cell cycle during which the cell performs its normal functions and its genetic material is copied in preparation for cell division.

It is necessary that the cell copies its DNA so that each of the daughter cells will have one complete copy. When a cell divides, it replicates a new complete set of chromosomes so that these instructions can be passed on to the daughter cells.

In humans, we start out with _____ chromosomes in our cells, (n = 23 pair) and after _____ we have a total of _____ chromosomes.
(FYI: the average strand of human DNA is ~ 5cm long and the diameter of each DNA is 2 nm = 0.000 002 mm.)

Chromosomes have small parts called **genes**. Genes are made of a chemical called **DNA**, genes always work in pairs. Genes control the development and inherited characteristics.
Chromosomes contain genetic material, DNA: instructions needed to build a whole new organism form a single fertilized egg cell. Chromosomes always work in pairs.
DNA must be copied (_____), so that when one cell divides into two cells, each cell gets a copy of all the _____ (genetic material), located in the nucleus.
Each thin strand of DNA called " _____", is copied or replicated, so that there are two sets of DNA.
The copies of _____ stay uncoiled for a while.
The replicated chromatin strands now coil into thick, large and dense double -stranded _____.
At this point, it is easier to see the _____ and the fact that they are joined together in the middle at a region called the _____.
This attachment ensures that the chromatids will remain paired through the early phases of the cell division, (mitosis).

DNA replication: the process by which DNA is copied, creating sister chromatids joined at the centromere.
Chromatid : one of two identical strands of DNA that make up a chromosome.
Sister chromatids: the identical "replicated" copies of a chromosome that are attached together.
Centromere: place at which the sister chromatids are joined together.
Spindle fibres: during mitosis the movement of chromosomes are controlled by spindle fibres, specialized structures that attach to the centromeres of each chromosomes. Spindle fibres form during late interphase. During prophase and metaphase, the spindle fibres pull the chromosomes into the middle of the cell. During anaphase, the spindle fibres pull the daughter chromosomes toward opposite ends of the chromosomes.
Spindle fibres, centrosome, and centromere all ensure that each of the sister chromatids becomes part of a different daughter cell.

CELL DIVISION

In general cell division will not occur if:
1. There are not enough nutrients to support cell growth,
2. If the DNA has not been replicated,
3. If the DNA is damaged

Cell division is a two part process: I. Mitosis II. Cytokinesis

I. THE FIRST STAGE OF CELL DIVISION: MITOSIS

(See Diagrams Below)

Mitosis is the normal cell division process that produces:
— cells needed to make an adult organism from a fertilized egg,
— cells needed to heal cuts, wounds, and broken bones,
— cells that replace dead skin cells, and worn out red blood cells;
— cells that let a seed grow into a plant, etc.

(Skin cells undergo mitosis more frequently than other cells because they are constantly replacing dead and damaged cells; and because skin is the largest organ.)

The process of mitosis is controlled by the nucleus. All the cells in animals and plants, **except** sex cells, are made by mitosis.

The purpose of Mitosis is to separate the replicated _____ into two _____ cells, called _____ cells.
It takes _____ phases to complete.
The cells move gradually from one phase to the next. Mitosis is a continuous, not discrete process.

Mitosis is a form of cell division resulting in the production of two new cells, (i.e. the daughter cells), each new cell has a nucleus with a complete set of DNA as the parent cell.

Note: chromosomes are visible during mitosis but not at other times, because chromosomes are condensed during mitosis.

The four phases of mitosis are: 1. Prophase, II. Metaphase III. Anaphase IV. Telophase

Phase I: PROPHASE

(Prophase: *pro* is Latin for: before, in advance, taking the place of, e.g. prologue, prolife, pronoun, prototype, proline, etc.)

- When prophase begins, the double stranded chromosomes are large and dense enough to be seen with a light microscope. Each chromosome has two identical copies called a '**chromatid**', which are linked at a **centromere**. (A copy of the genetic material must be made so that each new cell that is formed by cell division will have a complete set of genetic information.)
- The **nucleolus** and the **nuclear membrane** disintegrates and the chromosomes are free to move within the cell. (The nuclear membrane must break down in mitosis to allow the divided nucleus to move prior to cytokinesis.)
- **Centrioles** move to the opposite ends of the cell.
- In animal cells, **spindle fibres** begin to form and stretch across the cell.
- Spindle fibres attach to one side of each centromere that hold the replicated chromosomes.

Phase II: METAPHASE

(Metaphase: *meta* is Latin for: middle, later, next, between, e.g. metamorphosis, metaphor, metabolism, etc.)

- The tugging action of the spindle fibres pulls the double-stranded chromosomes into a line across the middle of the cell, i.e. the **equatorial plane** of the cell.

Phase III: ANAPHASE

(Anaphase: *ana* is Latin for : up, back again, renewal, e.g. anagram, analog)

- The spindle fibres begin to contract and shorten.
- This action pulls the centromere apart allowing one of each of the replicated strands to move to the opposite poles of the cell, i.e. away from the center.

Phase IV: TELOPHASE

(Telophase: telos: end, completion, e.g. telocentric)

- One complete set of chromosomes is now at each pole of the cell.
- The spindle fibres begin to disappear.
- A nuclear membrane forms around each new set of chromosomes.
- A nucleolus appears within each new nucleus.
- Single -stranded chromosomes start to uncoil into thin strands of chromatin (DNA).
- Now there are two nuclei in one cell and the cell is therefore ready to divide.

It is necessary for a new nuclear membrane to form around each group of daughter chromosomes during telophase, because when the cell is split, it is critical for each new cell to have its own distinct nucleus to start directing the life activities immediately.
At the end of telophase, the cell has two nuclei.

Prophase and telophase are opposite of each other :

Prophase	**Telophase**
1. chromosomes coil and become visible appear	1. chromosomes uncoil and become invisible
2. nuclear membrane disappears	2. nuclear membrane reforms
3. nucleolus disappears	3. nucleolus appears
4. spindle fibres form and attach to chromosomes	4. spindle fibres break down.

II THE SECOND STAGE OF CELL DIVISION: CYTOKINESIS

After the telophase, the cytoplasm of the cell will completely divide and the cell membrane pinches in to create a cleavage furrow until the mother cell is pinched in half forming two new genetically identical cells, (called daughter cells): this process is called **Cytokinesis**, forming two new cells, each with its own nucleus containing chromatin.
Cytokinesis consists of actual division of the cell.

Once mitosis and cytokinesis is complete, the two daughter cells enter interphase, and the new cell cycle continues.
In plant cells. a **cell plate** develops across the center of the cell forming a **cell wall** between the two new cells.

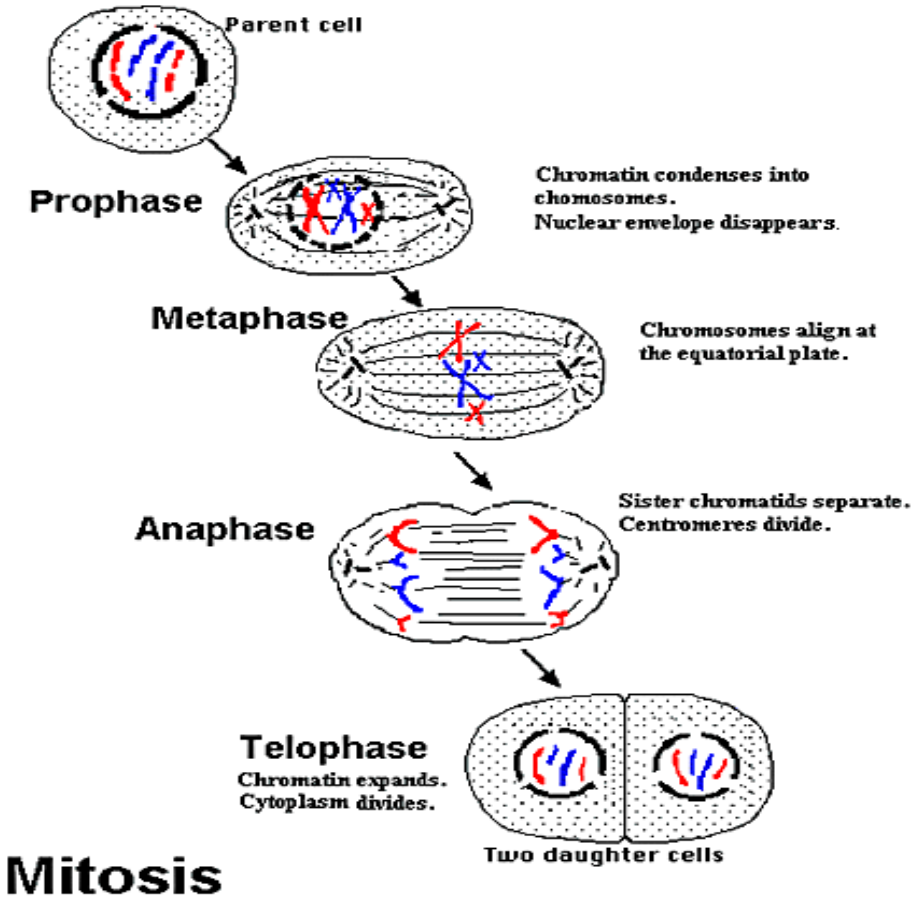
Difference between mitosis and cytokinesis

Mitosis is the stage in which the contents of the nucleus divide, i.e. mitosis consists only of steps that occur before the cell actually divides into two cells.
Cytokinesis is the final stage of cell division, where the rest of the cell divides into two genetically identical daughter cells. Cytokinesis is where the cytoplasm (rest of the cell outside the nucleus) divides.

Mitosis and cytokinesis are part of the entire process of cell division. The material in the nucleus divides by the process of mitosis, whereas the rest of the cell divides by the process of cytokinesis. The cell cycle is the process that includes cell division and interphase.

Cells have different life spans: stomach lining cells live for only 2 days because they are exposed to digestive enzymes, while brain cells live for 50 years.
Cells die because their life span is programmed into their genetic material, or because they are damaged and do not receive enough food or oxygen.

Illustration of the process of Mitosis



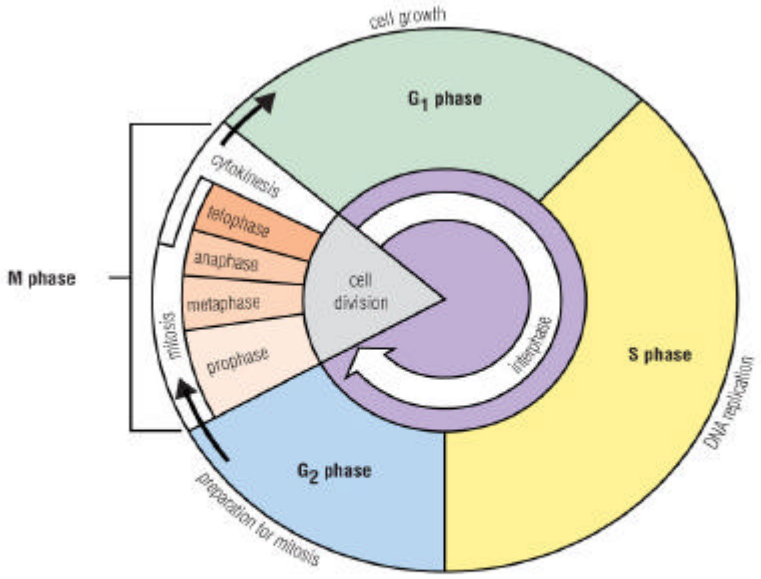


Figure 1.28 The cell cycle has four phases. During most of the cell cycle, the cell is growing, replicating its DNA, and preparing for cell division.

The Cell Cycle